

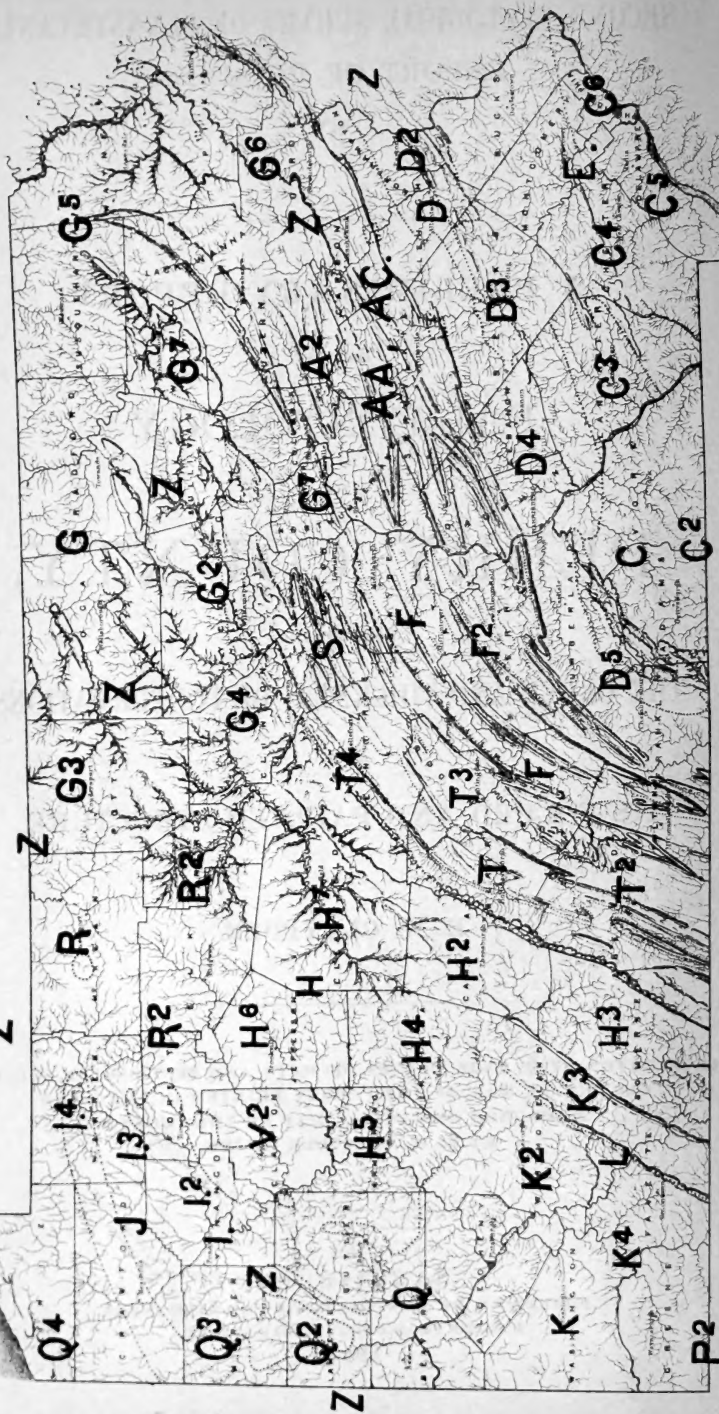






Geological Reports of Pennsylvania, 1874-1884.

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P.—Coal Flora. B, B², M, M², M³.—Chemical Analyses.

N.—Levels. O, O².—Catalogue of Specimens.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.
REPORT OF PROGRESS
F².

A PRELIMINARY REPORT
ON THE
PALÆONTOLOGY
OF
PERRY COUNTY,
DESCRIBING
THE ORDER AND THICKNESS OF ITS FORMATIONS
AND
ITS FOLDED AND FAULTED STRUCTURE.

BY
Edward
E. W. CLAYPOLE.

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ILLUSTRATED BY 48 PAGE PLATES OF MAPS AND SECTIONS; A COLORED
GEOLOGICAL MAP OF THE COUNTY PRINTED IN 1879; AND
A COLORED GEOLOGICAL MAP OF THE COUNTY
BY E. W. CLAYPOLE IN 1883.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY.
1885.

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LETTER OF TRANSMITTAL.

To His Excellency ROBERT E. PATTISON, *ex-officio* Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania :

SIR : I have the honor to transmit the first report of Prof. E. W. Claypole on Perry county, relating chiefly to its structural geology. The description of fossils and the discussion of purely palæontological subjects are reserved for another report.

The first five chapters I have edited and condensed, adding sundry geographical items to the first chapter. Prof. Claypole has read the proof of the printed text from page 113 onward. The Index I have myself compiled.

Two colored geological maps of Perry county accompany this report. One prepared by me in 1878, from the MS. maps and field notes of Mr. John H. Dewees, and from the State map of 1841-'2 (1858); the other by Prof. Claypole in 1883. The one ascribed to Mr. Dewees was drawn on stone and printed in 1879 by Bien & Co., and has ever since awaited the publication of Mr. Dewees' reports on Perry and Juniata counties—a publication delayed by various causes not needful to specify. This map may be more correct along the lines of fossil ore outcrop to which Mr. Dewees paid special attention, but is wholly incorrect along the Dick's ridge, Mahony ridge and Half-Falls mountain belt (the central belt of Perry county) so carefully studied and portrayed by Prof. Claypole.

The author's township outcrop maps are reproduced from the originals without change. No separate geological maps were made of Jackson, Madison and Toboyne townships on account of their mountainous and wild condition and lack of reliable geographical data.

His cross-sections I have redrawn to make the vertical scale correspond with the horizontal scale; and to make the outcrop-belts conform in width to the general scale of thicknesses given on page 32, and in Plate V, page 34. The plication of the underground rocks of Perry county is so great that its rock-beds come to the surface at all angles, from 1° to 90° ; and are even overturned in the south-east corner of the county where the older formations overlies those which were deposited upon them. (See the Index of Dips on pages 404, 405.)

In drawing cross-sections it is easy to exaggerate the amount of plication. To avoid such exaggeration, it is needful to execute them on one and the same scale, vertical and horizontal. If this be done, and the formation-thicknesses be only approximately correct, then the formation-dips will come right in spite of minute local variations. If, for example, the Oriskany outcrop No. VII and the Dellville sandstone outcrop at the base of No. IX be well marked on one of the township maps where the dip is all one way—and if there be 5600 feet of Marcellus, Hamilton, Genessee, Portage, Chemung, and passage beds of No. VIII—it follows that a cross-section on a dip of 33° will represent the structure with a close approximation to the truth.

If there should be a local thickening of the deposits of VIII to 6000 feet, or a local thinning down to 5000, then, instead of using for the cross-section a dip of 33° , one must use 35° or 28° . It is plain, therefore, that very considerable errors in estimating the thicknesses of the formations will produce a hardly appreciable effect upon the character of the cross-sections if they be drawn to a true scale both vertical and horizontal, provided fixed points of reference have been secured upon the map.

I have constructed six sections on Plate IV, page 32, partly to exhibit this truth, and partly to show that the apparently excessive plication of Perry county is not of an extraordinary kind, nor so great as that of the Anthracite coal basins.

I had also in view the illustration which it affords of a

law first discovered by Dr. Whelpley in 1838, that the plications of a great system of rocks are not regular from top to bottom; that the set visible at the surface does not correspond exactly to those concealed beneath the surface; and that a few great folds in the massive sand-rocks are represented by a much larger number in the overlying or underlying soft formations.

Thus, the two great basins and the great intermediate arch in the upper formations at the east end of Perry county are represented by many smaller arches and basins in the lower formations at its western end; and we may believe that if we could get data for constructing a true cross-section on a plane 10,000 or 15,000 feet beneath the Susquehanna river it would exhibit a similar series of small arches and basins.

I have also endeavored to show, on Plate IV and on other plates, how faults at the surface must necessarily terminate downward in unbroken folds whenever the dip is stronger on one side of the fault than on the other, no matter at what angle the fault-plane itself may stand; that the upthrow must necessarily take place on the side of the steeper dip; and that it must increase upward constantly. In horizontal rocks, in unplicated regions, faults may go to great depths; but in folded regions they must stop at some definite distance underground easily calculated by merely drawing a geometrically true cross-section.

The decided north-westward leaning of the Appalachian folds is shown in these Perry county sections; and it is well to call attention again to the smaller and more numerous folds in the lower formations in connection with this north-westward leaning, on the supposition of its being caused by a thrust from the south-east. No satisfactory explanation of the origin of such a thrust has offered itself. The fact itself seems to be undoubted; but whether the movement was one of the underlying Azoic foundation rocks, or whether it was confined to the superficial palæozoic formations sliding down a rigid inclined plane produced by the vertical elevation of the Azoic zones, is the first question. In the latter case it is easy to see how the

sliding mass would fold itself in overturns towards the bottom of the descent ; and it is also easy to see how friction on the rigid Azoic surface would not only limit the distance at which the movement would cease, but also cause the lower formations to be folded much more minutely and universally than the formations higher in the series, which would move with a certain freedom over them ; and this may guide us to an understanding of the extraordinarily close and collapsed crimples of the limestones and slates of the Cumberland valley, and to the origin of the numerous small folds of the roofing-slate belt of the Lehigh region.

On the other hand, having recently constructed a model of the State showing the upper surface of the Medina sandstone No. IV, with all its underground arches and troughs, and with these arches restored to their original heights in the air, I was surprised at the clearness of the testimony which it bears to the fact that a huge block of the Azoic country south of Harrisburg has been moved bodily north-westward at least ten miles, crushing the Palæozoic formations into concentric circular segments, the outer one having a radius of 120 miles struck from Port Deposit at the mouth of the Susquehanna river ; and that to this movement are due the overturn the Blue mountain rocks above Harrisburg, the four-mile fault and throw along the Chambersburg and Gettysburg turnpike, the McConnellsburg Cove upthrow of 8000 feet, the profound synclinal of the Broad Top, the great broken anticlinal at Tyrone City, and no doubt the faults in Perry county, at Orbisonia, at Greenwood furnace and elsewhere in middle Pennsylvania.

Such a movement, however, involving anticlinal arches five miles high, and synclinal basins correspondingly deep, could not take place without greatly disturbing the original thicknesses of the several formations, hard as well as soft ; nor without an enormous amount of irregular shifting of one formation upon another and shearing motion among the groups of beds ; as in fact the Anthracite survey has amply demonstrated. In view of this inevitable consequence of such a transfer of the parts of the Palæozoic system from place to place, I cannot consider it quite certain

that the remarkable disappearance of outcrops (Marcellus, Oriskany, Little Helderberg and Upper Onondaga) along the line of the *overturn*—that is along the Blue mountain for some miles west of the Susquehanna river in Perry county and for some miles east of the river in Dauphin and Lebanon counties—can be wholly explained by an original lack of the sediments in a shallow or dried up sea. It is very remarkable that this failure of the formations should happen just along the line of maximum thrust and slide,—just where the whole mass was turned over beyond the vertical upon its face,—therefore, just where the greatest amount of *shearing motion* must have occurred,—in fact, just where we should expect an upthrow fault with all its consequences.

Prof. Claypole has presented the arguments for shallow water on pages 37 and 393 ; and they have force ; but there are dark places in the line of argument of this question pursued by geologists in other parts of the world ; and the evidence from pebbles must be considered of little weight since the researches of M. Delesse in the waters of the bay of Biscay, and the remarkable discoveries of large pebbles in considerable numbers in very deep water off the Atlantic seaboard made by the dredging parties of the U. S. Coast Survey and published recently by Prof. Verrill. Even the coralline beds of the Lower Helderberg, mentioned on pages 160, 182, 338, are not conclusive evidence of shallow water, unless it be proved that the original reef is in place. Detritus of coral reefs is carried far out into deep water ; and the multitudes of disjointed encrinite stems found in the Lower Helderberg and Hamilton formations (pp. 62, 206, 260, 343) may have been distributed over a deep ocean bed.

No geodetic instrumental work has been done in Perry county. Consequently the limits of the outcrops of the formations are drawn only *provisionally* upon the township maps (which are not very reliable) and must be corrected by the local knowledge of the citizens of the county. They will serve very well for a description of the geology of the county, but must not be relied upon for local exploration. They will be very useful to guide explorers in a

general way; but when it comes to tracing and opening special beds, then a specially accurate local survey must be made by those interested.

In presenting this report, it is my duty to remind the Board that Prof. Claypole was commissioned by it for a particular purpose, namely, to study the fossils of Perry and Juniata counties, and to discover the locality and range of each species in the pile of formations; in other words, to learn what genera and species of animal form, characterize the different rock-deposits which outcrop along the Juniata river. In the pursuit of this business he was compelled to acquaint himself with the order of the rock-deposits, and to define their upper and lower limits, and their subdivisions. His attention was arrested near New Bloomfield by the irregular conjunction of certain formations which were elsewhere separated by hundreds or thousands of feet of intermediate deposits. The cause of this irregularity is shown on the plates which accompany the report, in the shape of two principal faults, or cracks in the earth, on one side of which the rocks are lifted and on the other side lowered, so as to bring into contact the edges of formations which ought to be far apart, at the present surface.

In other parts of the county he found disturbances of another kind interfering with his study of the fossils, viz: a crumpling of the deposits sideways, increasing their apparent thickness, and duplicating the same bed one or more times. This led him to a remeasurement of the formation-thicknesses.

The result has been this preliminary descriptive report on the *structural geology* of Perry county; and it will be noticed that only so much attention has been given to the economic geology, the fossil iron ore beds, the limestone quarries, and the worthless coal beds of Duncannon and Mt. Patrick, as came in the way of the main pursuit, and was necessary for the limitation of the formations. The discussion of the utility of lime on soils and the table of living plants were intended to be merely appendixes to the report.

An interesting feature of this report is the description which Prof. Claypole gives of the trap dykes of the Cove. Dr. Henderson's long dyke assumes a new aspect; and important conclusions may be drawn from the fact that four parallel dykes traverse the Cove, one of which crosses Cumberland county southward, and another projects itself northward beyond Halifax, in Dauphin county. The trend of these evidently profound cracks in the earth crust is diagonal to the middle radius of the concentric circular segments produced by the thrust already mentioned.

Prof. Claypole's researches in Perry county in 1882 and 1883 have resulted in important modifications of the knowledge obtained by previous surveys, especially in the following particulars:—

1. The limitation of the name *Clinton* to the lower division of that mass of shales and thin sandstones numbered V by the First Survey, no Clinton fossils having been found in the upper division.

2. The consequent establishment of the *Onondaga* formation, as embracing the upper 1600 feet of No. V, partly on stratigraphical and partly on palæontological grounds.

3. The demonstration of the absence of *Niagara* beds from No. V.

4. The demonstration of the absence of the *Corniferous limestone* group from the whole county, and the allotment of the strata hitherto considered as representing that group to the *Marcellus* subdivision of the Hamilton division of No. VIII.

5. The definition of 600 or 700 feet of shales, chiefly by their fossil forms, as *Upper Hamilton*, *Genesee* and *Portage* beds.

6. The demonstration of a fauna, partly Chemung, and partly peculiar, high up in the Catskill formation No. IX, and—

7. The systematic tracing of the richly fossiliferous Kingsmill sandstone along all the Catskill outcrops of the county.

The proofs of these propositions will be given in detail in the second part of his report.

The *Medina sandstone* No. IV seems to be barren of fossils; a few unidentified forms were obtained from the north slope of Conococheague mountain.

The *Clinton lower green shale* of No. V has proved to be very barren; only a few not yet studied forms were found in it. The *Iron sandstone* is occasionally very fossiliferous, yielding *Beyrichia lata* and *Calymene clintoni*. In this occur traces of the earliest vertebrate yet recognized in America: a spine* named by Prof. Claypole *Onchus clintoni*; broken and comminuted scales and plates; and small pellets, apparently coprolites. The *Upper green shale* has yielded *Beyrichia lata*, *Calymene clintoni*, and *Calymene niagarensis*. The *Ore sandrock* and *Sand vein ore bed* are often abundantly fossiliferous, but the forms are badly preserved: *Beyrichia lata*, *Calymene clintoni*, *Ormoceras vertebratum*. The limestone and shale beds above the sandrock are not fruitful of the Clinton forms, among which appears *Lingula oblonga*.

The *Onondaga red shale* of No. V has yielded few fossils, *Leperditia alta* being almost alone; but comminuted scales, probably of fish, were found at a few localities. The *Vari-gated shale* is almost equally barren; but *Leperditia alta* is very abundant in the beds near the top; and the very highest beds (*Bloomfield sandstone*) are made peculiarly interesting by Prof. Claypole's discovery in them of the shields of two kinds of fish, which he has named *Palæaspis americana* and *Palæaspis bitruncata*, and spines of small size, with fluted surfaces like those of Silurian fish, which he names *Onchus pennsylvanicus*.† In the *Water-lime group*, *Leperditia alta*, often of unusually large size, is the only fossil form abundant in Perry county; but a good specimen of *Pterygotus osborni* was obtained from Juniata county through Mr. James Stevenson, now of Akron, Ohio.

The *Lower Helderberg* formation No. VI is very fossil-

* Described in advance in the Quarterly Journal of the Geological Society of London. Meeting December 14, 1884.

† For a preliminary description and remarks, see American Naturalist, p. 1222, December, 1884.

iferous. The list of forms found in its soft shales is a long one, although these strata are seldom well exposed for examination, and most of the collections were made at a few points, chiefly Clark's mill near Bloomfield. *Lingula spatiosa*, *Lingula centrilineata*? *Atrypa reticularis*, *Spirifera vanuxemi*, *Spirifera saffordi*, *Rhynchonella nucleolata*, *Rhynchonella mutabilis*, *Meristella bella*, *Meristella lævis*, *Renssælia mutabilis*, *Discina ampla*, *Discina discus*, *Strophomena woolworthana*; *Euomphalus profundus*; *Megambonia aviculoidea*, *Modiolopsis dubia*, *Cypricardinia lamellosa*; *Leperditia alta*, *Beyrichia granulata*, *Beyrichia notata*; *Orthoceras longicameratum*; *Lepadocystites*; *Chætetes abruptus* have been determined.

No *Corniferous* fossils have been found.

In the *Marcellus* division of No. VIII appear *Atrypa reticularis*, *Leiorhynchus limitaris*, *Strophomena rugosa*, *Ambocælia umbonata*, *Discina seneca*, *Phacops rana*, *Beyrichia ungula* (new species), *Coleolus* (*Coleoprion*) *tenuicinctus*, *Styliola fissurella*.

The *Hamilton* division of No. VIII is as a whole the richest fossiliferous formation of the district, and the list here given might be considerably extended by further systematic collections; *Strophodonta perplana*, *Strophodonta inæquistriata*, *Vitulina pustulosa*, *Chonetes lepidus*, *Chonetes mucronatus*, *Chonetes setigerus*, *Discina media*, *Discina minuta*, *Atrypa spinosa*, *Atrypa aspera*, *Atrypa hystrix*, *Atrypa reticularis*, *Spirifera medialis*, *Spirifera fimbriata*, *Spirifera mucronata*, *Spirifera ziczac*, *Spirifera acuminata*, *Spirifera granulifera*, *Rhynchonella horsfordi*, *Leiorhynchus multicostratum*, *Ambocoelia umbonata*, *Cyrtina hamiltonensis*, *Pholidops hamiltonensis*, *Streptorynchus chemungense* (var.), *Productella truncata*, *Productella spinulicosta*, *Nucleospira concinna*, *Orthis penelope*, *Orthis vanuxemi*, *Crania hamiltoniæ*, *Cryptonella rectirostra*, *Tropidoleptus carinatus*, *Terebratulina lincklæni*, *Strophomena rhomboidalis*; *Loxonema delphicola*, *Nuculites oblongatus*, *Nuculites triqueter*, *Eodon tenuistriatus*, *Eodon bellistriatus*, *Sanguinolites truncatus*,

Orthonota carinata, *Orthonota undulata*, *Orthonota siliquoidea*, *Modiomorpha concentrica*, *Modiomorpha alta*, *Modiomorpha complanata*, *Nucula bellistriata*, *Nucula lirata*, *Palæoneilo fecunda*, *Palæoneilo filosa*, *Palæoneilo emarginata*, *Palæoneilo muta*, *Palæoneilo maxima*, *Goniophora hamiltonensis*, *Goniophora truncata*, *Macrodon hamiltonia*, *Cypricardinia indenta*, *Actinoptera decussata*, *Nuculana diversa*, *Aviculopecten orbiculatus*, *Paracyclas lirata*, *Actinodesma subrectum*; *Pleurotomaria trilix*, *Pleurotomaria sulcomarginata*, *Pleurotomaria capillaria*, *Bellerophon thalia*, *Bellerophon patulus*, *Bellerophon crenistriatus*, *Bellerophon leda*, *Cyrtolites pileolus*, *Platyceras carinatum*; *Coleolus acicula*, *Coleolus tenuicinctus*, *Tentaculites gracilistriatus*, *Styliola fissurella*, *Conularia continens*; *Taniopora exigua*, *Aulopora tubiformis*; *Dalmanites calliteles*, *Phacops rana*, *Proetus macrocephalus*, *Homalonotus dekayi*, *Beyrichia punctulifera*. The characteristic forms of the subdivisions of the group will be separated in Part II of this report.

The *Genessee* division of No. VIII, supposed to be represented by 200 feet of shales overlying the Hamilton is destitute of fossils.

The *Portage* division of No. VIII may be represented by a succeeding mass of black shale containing *Cardiola speciosa*, &c.

The *Chemung* division of No. VIII has afforded *Productella hirsuta*, *Cyrtina hamiltonensis*, *Strophodonta perplana*, *Orthis impressa*, *Atrypa reticularis*, *Spirifera mesocostalis*, *Spirifera mesostriatis*, *Leiorhynchus mesocostalis*, *Chonetes logani*; *Palæoneilo filosa*, *Palæoneilo constricta*, *Modiomorpha concentrica*, *Modiomorpha subalata*, *Eodon bellistriatus*, *Grammysia elliptica*; but the Chemung proper has not proved rich in fossils in Perry county, and their fragmentary condition adds to the tediousness of collecting a complete suite. The areas are very large, especially in the northern townships, where the formation is at least twice as thick as it is in the southern, and where good exposures are not numerous and the country is wooded. In the southern townships exposures are redu-

plicated by the rock folds, which, however, have distorted and broken the fossils.

The *transition Chemung-Catskill* strata which may be regarded by some as at the top of No. VIII, and by others as at the bottom of No. IX, contain numerous lamelli-branches, while the brachiopods become fewer in proportion. The beds containing these fossils, so far as their true position can be determined, lie high up in the series, and above red beds of shale containing the well known Catskill fish *Holoptychius* and *Bothriolepis*, if these be really distinct. Prof. Claypole has arranged a list of such fossils as occur above the fish-bed and up to the horizon where in his district he found the last traces of a Chemung type. "Many hundred feet of shale and sandstone, mostly red, here occur, some containing fish-scales and other Chemung fossils, until the great red mass of the Catskill proper is reached, which here, as elsewhere, is almost barren of remains of animal life:"—*Spirifera mesostrialis*, *Spirifera disjuncta*; *Sanguinolites undatus*, *Goniophora chemungensis*, *Modiola metella*, *Schizodus oblatius*, *Schizodus chemungensis*? *Schizodus rhombeus*, *Lyriopecten priamus*, *Actinoptera zeta*, *Cardiomorpha rotunda*; *Bellerophon maera* (var.); *Holoptychius americanus*, *Bothriolepis taylori*. "Other undescribed forms also occur in these beds; and it is worthy of remark that many of the identified fossils show some variation from their figures and descriptions, probably the result of conditions of life for the most part unfavorable."

From the *Catskill* formation No. IX nothing has been obtained but a few plant remains.

From the *Pocono* formation No. X only a few drifted logs of *Lepidodendron* were seen.

In the *Mauch Chunk* formation No. XI no trace of organic life was noticed.

In the Second Part of Prof. Claypole's report he will present the evidence which the several localities have furnished for the correctness of his conclusions, in greater detail, and with illustrations of the fossils which are not yet sufficiently prepared for publication. Meanwhile the First

xvi F'. REPORT OF PROGRESS. E. W. CLAYPOLE.

Part now presented will be of public use to all citizens of Perry county who are interested to understand the geology of their vicinity.

J. P. LESLEY.

PHILADELPHIA, *1008 Clinton street.*

February 9, 1885.

TABLE OF CONTENTS.

CHAPTER I.

	Page.
Physical geography of the county; townships; towns and villages; mountains and hills; rivers, creeks and runs; canal and railroad levels; valleys;	1

CHAPTER II.

Geological structure of the county; subplications; faults; table of formations;	31
--	----

CHAPTER III.

Description of the formations.

III. Utica and Hudson river shales,	43
IV. Oneida and Medina sandstones,	43
Va. Clinton group,	44
Comparison with New York,	46
Clinton lower green shale,	47
Block ore and iron sandstone,	48
Clinton upper shale,	48
Sand rock and sand vein ore bed,	49
Niagara group wanting,	52
Vb. Onondaga red and variegated shales,	53
Bloomfield sandstone,	54
Onondaga gray shales,	55
Bridgeport sandstone,	57
VI. Lower Helderberg group,	58
VII. Oriskany sandstone,	62
Upper Helderberg wanting,	64
VIIIb. Marcellus limestone and black shale,	64
2 F ^a	(xvii F ² .)

	Page.
VIIIc. Hamilton lower shale,	66
Hamilton sandstone,	67
Hamilton upper shale,	68
VIIIId. Genessee group,	69
VIIIe. Portage group,	69
VIIIIf. Chemung group,	70
IX. Catskill formation,	72
Fish beds,	73
Kingsmill sandstone,	73
Kingsmill shales,	77
Dellville sandstone,	77
Catskill upper beds,	78
X. Pocono sandstone,	78
XI. Mauch Chunk red shale,	79
Volcanic rocks; trap dykes,	79

CHAPTER IV.

The Perry county fault,	81
Half Falls fault,	88
Little Germany fault,	89
Intermediate fault,	91

CHAPTER V.

Clinton fossil iron ore beds,	91
Marcellus brown hematite bed,	96
Hamilton (Montebello) fossil iron ore,	99
Oriskany ferruginous beds,	101
Portage-Chemung iron ore,	101
Catskill iron ore,	102
Pocono iron ore,	102
Lime and its use upon land,	103
Coal in Perry county,	107

CHAPTER VI.

Catalogue of living plants,	113
---------------------------------------	-----

CHAPTER VII.

	Page.
Geological descriptions of townships in alphabetical order:—	
1. Buffalo,	147
2. Carroll,	157
3. Centre,	169
4. Greenwood,	213
5. Howe,	223
6. Jackson,	229
7. Juniata,	235
8. Liverpool,	241
9. Madison,	247
10. Miller,	265
11. Oliver,	277
12. Penn,	283
13. Rye,	303
14. Saville,	319
15. Spring,	331
16. Toboyne,	349
17. Tuscarora,	361
18. Tyrone,	367
19. Watts,	377
20. Wheatfield,	387
<hr style="width: 10%; margin: 20px auto;"/>	
Index,	399 to 437



LIST OF PAGE PLATES.

	Page.
1. Map of No. IV mountains,	6
2. Fall of the Susquehanna river,	18
3. Geological structure, Figs. 1, 2, 3, 4,	30
4. Six cross sections of the great arch,	32
5. Table of formations,	34
6. Four figures of the Perry county fault,	82
7. Maps and sections of the fault,	84
8. Ore and coal sections,	92
8(b). Section of tunnel mine, fossil ore,	112
9. Map of Buffalo township and section A B,	146
10. Map of Carroll township,	156
11. Local map and cross section A B,	158
12. Map of Centre township,	168
13. Cross section A B,	170
14. Cross section C D,	172
15. Local map and small section,	174
16. Four small sections,	176
17. Local map and small sections,	178
18. Map of Greenwood township and two sections,	212
19. Cross section A B,	214
20. Map of Howe township and section A B,	222
21. Columnar section in Jackson township,	228
22. Map of Juniata township and section A B,	236
23. Map of Liverpool township and section A B,	240
24. Local map and sections, Madison township,	246
25. Two sections,	248
26. Two quarry sections,	250
27. Centre mills section,	252
28. Map of Miller township and section A B,	264
29. Map of Oliver township and section A B,	274

	Page.
30. Map of Penn township,	284
31. Local map and cross section,	286
32. Two columnar sections,	288
33. Map of Rye township,	302
34. Cross section and nonconformability,	304
35. Map of Saville township,	318
36. Cross and columnar sections,	320
37. Map of Spring township,	330
38. Cross section A B,	332
39. Little Germany fault,	334
40. Cross and columnar sections in Toboyne township,	350
41. Map of Tuscarora township,	360
42. Map of Tyrone township,	366
43. Cross and columnar sections,	368
44. Map of Watts township and section A B,	376
45. Map of Wheatfield township,	386
46. Cross and columnar sections,	388
47. Old map of the Susquehanna, 1701,	396
48. Section across Tuscarora township,	398

PERRY COUNTY.

CHAPTER I.

Physical Geography of the county.

Perry county is bounded on the east by the Susquehanna river, from five miles above Liverpool down to the gap in the Blue mountain,* four miles above Harrisburg, a distance of 21 miles as the crow flies, and of 29 miles along the windings of the river bank.

The southern line, adjoining Cumberland county, follows the crest of the Blue mountain westward for a length of 53 miles. From corner to corner, if measured on a straight line S. 10° W., the distance is 38½ miles.

For the entire distance the mountain is unbroken by a single gap deep enough to pass a stream. With the exception of two or three slight notches or air-gaps, the crest maintains a uniform height of about 1000 feet above the Cumberland valley to the south. But the course of the mountain (and therefore of the county line upon the map) is by no means a straight line. For the first 22 miles from the river it is nearly straight, due westward. Then it curves back northward to Welsh hill and makes a loop (called by the people of the neighborhood Green valley). Coming out again as far as before, to Pilot knob, it makes a second and deeper loop called Kennedy valley. Hence its course is nearly straight (S. 30° W.) for 16 miles, to the Franklin county line corner.

* Known to the settlers on the lower Susquehanna as the First mountain, further west as the North mountain, and further east, in Schuylkill, Lehigh, and Northampton counties as the Kittatinny mountain, which name was adopted by Prof. Rogers in his final report of 1853.

The southwestern boundary line, adjoining Franklin county, is a series of nearly right angled jogs. Commencing on the south at the Blue mountain crest, it crosses Henry valley to Little Round Top and Round Top, and Horse valley to the crest of West Tuscarora mountain, the air-line distance from corner to corner being $8\frac{1}{4}$ miles.

The north-western boundary, adjoining Juniata county, would be a nearly straight line (E. N. E.) 45 miles long, were it not for two small offsets to the northwest, thus: crest of W. Tuscarora mountain (nearly straight, E. N. E.) 10 miles; offset to the northwest across Liberty Valley to the top of Tuscarora mountain, $1\frac{3}{4}$ miles; along crest of Tuscarora mountain, (nearly straight, E. N. E.) to the Juniata river, $22\frac{1}{2}$ miles; offset to the northwest, $1\frac{1}{2}$ miles; thence nearly straight (E.) $12\frac{3}{4}$ miles to the Susquehanna river.

The shape of Perry county is therefore that of a slightly curved blunt wedge, about 15 miles wide at its eastern base and 8 miles wide at the south-western edge, with an average medial length of 40 miles.

It is said to contain 539 square miles, or 344,960 acres,* of which at least one fourth may be said to be occupied by ranges of mountains from 600 to 1200 feet high,† covered in large part by forest trees of the second, third, or fourth growth, and separated by arable valleys, mostly narrow and long, and by glens heading up between the ends of the mountains. The larger valleys in the eastern part of the county are sub-divided by low ridges, also much wooded, but mainly cultivated.

The population of Perry county in 1860, was 22,793; in 1870, 25,447; in 1880, 27,522.

Townships.

There are twenty townships in the county, five of which border on the Susquehanna river, viz: *Liverpool*, *Buffalo*, *Watts*, *Penn*, and *Rye*; five occupy the triangular space between the Susquehanna and Juniata rivers, viz: *Liver-*

* Walling & Gray's Atlas of 1872.

† Measured from the valley beds alongside, but from 800 to 1600 high above ocean level.

pool, Buffalo, Watts, *Greenwood*, and *Howe*; five border on the west bank of the Juniata river, viz: *Tuscarora*, *Oliver*, *Miller*, *Wheatfield*, and *Penn*; seven border on the north line, viz: (from east to west) *Liverpool*, *Greenwood*, *Tuscarora*, *Saville*, *Madison*, *Jackson*, and *Toboyne*; seven border on the south line, viz: (from east to west) *Rye*, *Carroll*, *Spring*, *Tyrone*, *Madison*, *Jackson*, and *Toboyne*; and two occupy the center, viz: *Juniata* and *Centre*.

Madison, *Jackson*, and *Toboyne* therefore entirely cross the county in succession at its western end.

The arrangement may be thus exhibited:

			Tuscarora ||	Greenwood	Liverpool ||
		Saville		=	
			Juniata	Oliver ||	Howe
					Buffalo ||
	Madison			=	
Jackson		Tyrone	Centre	Miller ||	Watts ||
Toboyne					= =
		Spring		Wheatfield ||	
			Carroll		Penn ||
					Rye ||

Towns and Villages.

The following names will occur more or less frequently in this report, especially in connection with the lines, belts and zig-zag outcrops of the various formations. Although they can all be found in the index (wherein reference will be given to every page on which a name occurs) it will be well for the reader to see them here arranged in the order of the townships (from north to south and from east to west) in which they severally belong.

LIVERPOOL.—*Liverpool P. O.*, on the Susquehanna river, just north of and in front of the Buffalo mountain gap.

BUFFALO.—*Mt. Patrick*, on the river, just north of the Berry's mountain gap. *Montgomery*, on the river, 2 miles south of *Mt. Patrick* and $1\frac{1}{2}$ north of the east end of Half Falls mountain.

WATTS.—*New Buffalo*, on the Susquehanna river, $4\frac{1}{2}$ miles above the mouth of the Juniata.

GREENWOOD.—*Millerstown*, on the Juniata, one mile south of the bend at the east and of *Tuscarora* mountain. *Liberty Hall*, on the eastern township line, 2 miles from the

southeast township corner. *Pfoutz valley* occupies the northern part of the township, and *Wild Cat valley* the southern.

HOWE.—No village is notable in this small township, the northern part of which is covered by the rough ground of Buffalo and Berry's mountains, which unite and terminate westward at the Juniata river.

TUSCARORA.—*Donally's Mills*, on Raccoon creek, which traverses this long narrow township from end to end, at the south foot of the Tuscarora mountain, 5 miles west of the Juniata.

MILLER.—*Bailysburg*, (Old Caroline Furnace,) on the Juniata river and Pennsylvania railroad, $4\frac{1}{2}$ miles (by rail) east of Newport, and $1\frac{1}{2}$ miles west of the gap through Lime-stone ridge.

WHEATFIELD.—*Montebello*, 5 miles west of the Juniata river, and 1 mile southwest of the bend of the Little Juniata, now totally abandoned except one cottage. *Delbille*, on Sherman's creek, 5 miles west of the Susquehanna river.

PENN.—*Duncannon*, on the Pennsylvania railroad at the mouth of the Little Juniata and of Sherman's creek, and $\frac{3}{4}$ mile above the gap in Peter's or Third mountain. *Baskinville*, at the mouth of the Juniata river, one mile north of Duncannon.

RYE.—*Marysville*, on the Pennsylvania and Northern Central railroads, at the west end of the Pennsylvania railroad bridge, south of the gap in Second mountain. *Keystone*, on Fishing creek, 7 miles west of the Susquehanna river. *Grier's Point*, on Fishing creek, at the western township line, 10 miles west of the Susquehanna river.

JUNIATA.—*Juniata* (or *Milford*), at the horseshoe bend of Buffalo creek (which traverses the township from west to east,) 3 miles from the Juniata, and $\frac{3}{4}$ mile from the eastern township line. *Markelsville*, also on Buffalo creek, 4 miles west of Juniata (Milford.)

OLIVER.—*Newport*, on the Juniata river and Pennsylvania railroad, one mile below the mouth of Buffalo creek.

CENTRE.—*Bloomfield* (*New Bloomfield*), the county seat,

in the centre of the township. *Mannsville*, on Little Buffalo creek, in the northwest corner of the township.

CARROLL.—*Shermansdale*, at the great bend of Sherman's creek, $4\frac{1}{2}$ miles above (S. W. of) Delville, and 3 miles west of Grier's Point.

SAVILE.—*Ickesburg*, on Ickes' branch of Buffalo creek, $1\frac{1}{2}$ miles south of the foot of Tuscarora mountain. *Roseburg*, on Buffalo creek, 2 miles south of Ickesburg and 12 miles west of the Juniata river.

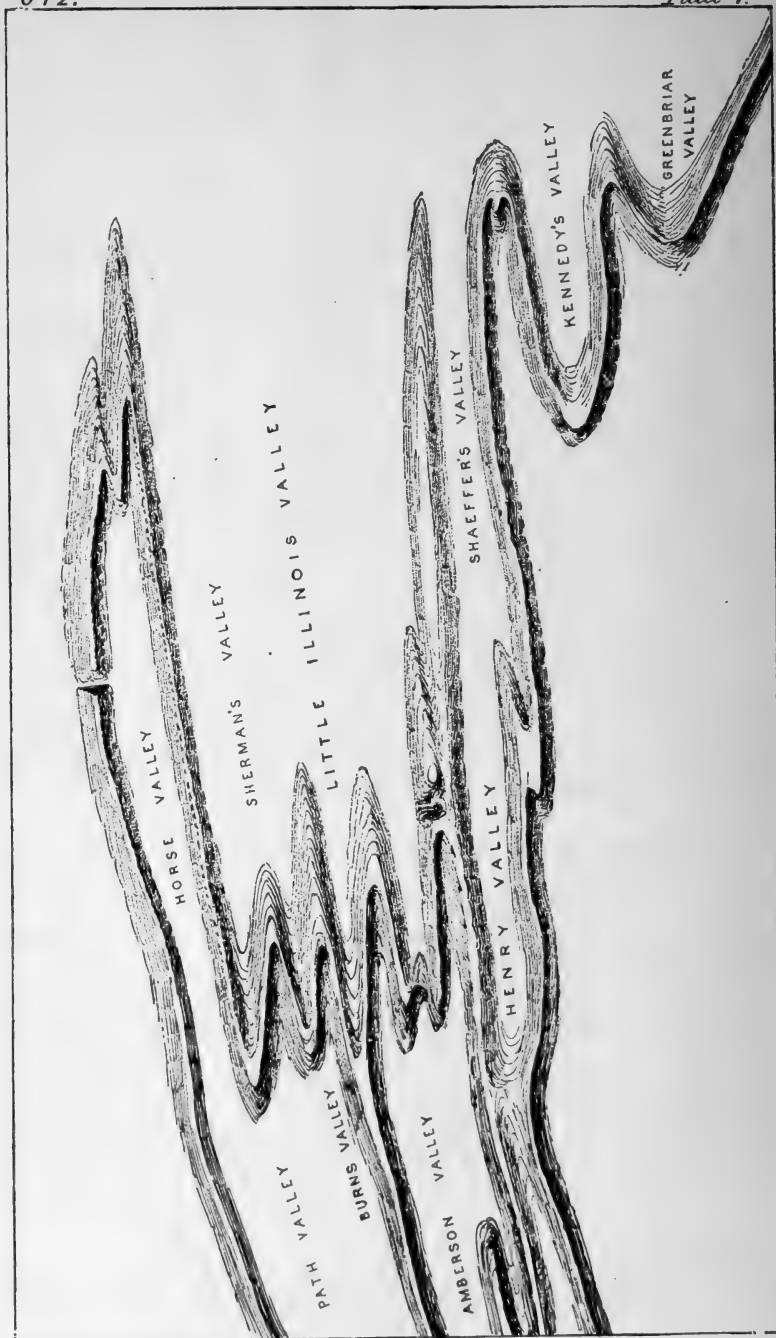
SPRING.—*Elliottsburg*, on Montour run (a branch of Sherman's creek,) in the northern corner of the township. *Bridgeport*, on Sherman's creek where it crosses the western township line. *Oakgrove*, on the Green Valley branch of Sherman's creek, 2 miles north of the southwestern corner of the township, site of one of the five old charcoal furnaces of the county.

TYRONE.—*Loysville* (*Andesville*), on Andes' branch of Sherman's creek, 1 mile from the northern township line. *Green Park*, on Montour run, 2 miles east of Loysville, and close to the eastern township line. *Landisburg*, $\frac{1}{2}$ mile north of the mouth of Montour run, and $\frac{1}{2}$ mile from the eastern township line.

MADISON.—*Centre*, on Sherman's creek, $3\frac{1}{2}$ miles west of Loysville. *Sandy Hill*, near the eastern township line, 3 miles north of Centre. *Andersonburg*, on Anderson's run, $1\frac{3}{4}$ miles from its junction with Sherman's creek, and $\frac{1}{2}$ mile from the western township line.

JACKSON.—*Beavertown*, near the center of the township, $\frac{1}{2}$ mile south of Sherman's creek. *Blain*, $1\frac{1}{2}$ miles N. W. of Beavertown and north of Sherman's creek. *Mt. Pleasant*, $2\frac{1}{2}$ miles west of Beavertown and north of Sherman's creek. The rest of the township is very mountainous and hilly.

TOBOYNE.—*New Germantown*, on Sherman's creek, 1 mile from the eastern township line. *Centreville*, on Sherman's creek, $1\frac{1}{4}$ miles west of New Germantown. *Fairview* (tannery) near the head of Sherman's creek, 4 miles west of New Germantown. *Horse Valley, P. O.*, near the northwestern corner of the township and county, behind (N. W. of) the Conococheague mountain. *Monterey* (tannery) on Hous-



ton's run, (a southern branch of Sherman's creek,) 3 miles southeast of New Germantown, and near the eastern township line. Most of this township is very mountainous and wild.

Mountains and Hills.

Five separate ranges of mountains traverse parts of the county, and three distinct ranges of lower hills.

Three of the five mountain ranges are of one geological character and physical form. The other two have a different form, and are of a different age and constitution, but, although separate in Perry county, are alike, and actually unite to form one range in Dauphin county.

One of the three hill-ranges zigzags continually to and fro throughout the county. The other two are of a different shape and age, but like each other form two great loops across the eastern half of the county; and the inner legs of these loops unite in Dauphin county.

The colored geological map which accompanies this report expresses very clearly to the eye the courses of these ranges, both of the mountains and of the hills, each range keeping strictly within its own belt of color, and being broken for the most part only by water-courses.

*Mountains of No. IV (Medina and Oneida.)**

(1.) *East Tuscarora* mountain forms one range by itself; and along its crest, for a distance of twenty-one miles† runs the northwestern county line. It is almost perfectly straight and continuous, except that it is gashed by a ravine opposite Ickesburg.‡ The little stream which flows down this ravine drains a small cove or vale in the heart of the mountain, 3 miles long by half a mile wide and pointed at both ends. The mountain is therefore double for a short distance, having two crests, along the southern one of which runs the county line, the other crest traversing Juniata

* See these mountains on page plate I.

† The total length of the mountain, measured by its crest, is about 24 miles.

‡ 14 miles from its east end at the Juniata river.

county. The mountain dies down gently at both ends; and around both ends fold its foot hills in sharp semi-ellipses.

(2.) *West Tuscarora* mountain, *Conecocheague* mountain, *Round Top*, *Little Round Top*, *Rising* mountain, *Amber-son* ridge, and *Bower* mountain* are all merely longer or shorter zigzags of one range, which encloses Jackson and Toboyne townships at the southwest end of the county, as shown by the yellow color on the map.

A woodsman can enter Perry county from Franklin county on the rocks at the top of the *West Tuscarora* mountain, and walk along the rocky crest of this range, alternately towards the northeast and towards the southwest, for a total distance of 35 miles, reëntering Franklin county by the crest of *Bower* mountain, only 3 miles across from the place where he left it. In all this distance he will keep at nearly the same elevation, say 1600 feet above ocean level, except at three points, where the wall on the top of which he is traveling is broken down to its base by small streams. One of these water gaps is cut through the *West Tuscarora* mountain; a second is made by the head of *Sherman's* creek, which cuts through *Rising* mountain; the third is made by *Houston's* run through the north leg of *Bower* mountain. Everywhere else along the line he will find the sharp crested mountain unbroken by gaps, with steep rock-covered slopes or even cliffs always on his right hand, and a gentler, smoother, but still quite steep slope on his left hand. When he turns the east end of a zigzag he will see the mountain crest make a long slope downward into the valleys of Perry county; and when he turns the west ends of the zigzags, he will be on boldly scarped knobs overlooking the shale and limestone valleys of Franklin county. On these knobs he will always reach a somewhat higher elevation above tide. *Round Top* and *Little Round Top* are simply the southwestward looking ends of two of the zigzags rather more strongly pronounced than the others. (See Figs. 2 and 3 on page plate I.)

(3.) *The North, Blue*, or *Kittatinny* mountain carries the

* Named thus in this order from northwest to southeast across the west end of the county.

southern county line, and is similar in form and character to those just described, having two large zigzags in its course.

Its total *crest-length* is 53 miles, unbroken by a single water-gap; but in a straight line from county corner to county corner, the distance is only 38 miles.

For 17 miles it runs (with one small zigzag) parallel to Bower mountain, separated from it by Henry valley, the deep and narrow vale of the north branch of Laurel run, which heads at the Franklin county line. Both mountains run on thus southwestward through Franklin county, unite and end before reaching Loudon. Bower mountain, therefore, is only a long return-zigzag of Blue mountain.

The mountain ends (so far as Perry county is concerned) at the Susquehanna river, 4 miles above Harrisburg; but, in point of fact, this is merely a wide water-gap in it; for its rocks rise as boldly again on the east bank of the river, and its crest continues on for nearly two hundred miles, in the same E. N. E. direction (broken at intervals by the water-gaps of the Swatara, Schuylkill, Lehigh, and Delaware rivers) to the real terminus of the mountain, not far from Newburgh on the Hudson river.

Along its whole course it preserves its shape of a monoclinal ridge, from 1200' to 1400' high above the river-water in the gaps, with a comparatively long smooth slope to the north, and a steeper rougher slope towards the south, sometimes crowned with low cliffs of coarse sandstone.

The mountain received the name of *First mountain* from the early settlers of Southeastern Pennsylvania, especially those who built their cabins along the Susquehanna river at Columbia, Marietta, and Harrisburg, and had occasion to canoe the river upwards through the water-gaps. The *first* mountain they passed through was the Blue mountain; the *second* was Cove mountain, and from the Susquehanna to the Lehigh it has retained the name of Second mountain ever since; the *third* was the Sharp mountain of Schuylkill county, which traverses Dauphin county, but does not reach the Susquehanna river; the *fourth* was Peters' mountain, on the east or Dauphin side of the river, and the short north leg of Cove mountain on the west or Perry county

side. Here the numbering stopped at the mouth of the Juniata. The mountains further north gapped by the Susquehanna were called Berry's and Buffalo mountains.

Mountains of No. X (Pocono.)

In Perry county there only remain to be described the *Second* and *Fourth* mountains, *i. e.*, the two legs of Cove mountain, and *Berry's* and *Buffalo* mountains, which also unite and form a cove. The gray color of these mountains on the map shows that their crests are made by the hard beds of the Lower Carboniferous *Pocono sandstone, No. X.*

(4.) The *Cove* mountain, then, in the south eastern corner of Perry county, is merely a sharply recurved ridge, about 1000' high above the water in the gap, the cut-off prow of a canoe-shaped basin, the Dauphin county anthracite coal basin,—the west end of a long-pointed ellipse*—diagonally traversed by the Susquehanna river, so that its south reach of crest is 10 miles long, and its north reach of crest only 5. The two crests unite in a slightly elevated knob at the west end, overlooking the fertile valley of Sherman's creek.

The shape of the *Cove* mountain differs from that of Blue, Bower, Rising, Round Top, Conecocheague, West and East Tuscarora mountains of the 1st, 2d, and 3d ranges already described in two essential points: First, its rocks are of later age and different constitution (see further on;) and Secondly, its cross-section is not that of a sharp crest and two slopes. *Cove* mountain has a long, gentle, smooth slope on its inner side, *i. e.*, into the Cove, and a bold terrace on its outer side (southward towards the Blue mountain, and northward towards Sherman's valley) cut by ravines, and sometimes quite separated from the mother mountain as a distinct and lower ridge, composed of the hard beds of the Catskill formation No. IX.

The explanation and representation of this peculiar form is reserved for the geological description, further on. See report on Penn township.

(5.) *Berry's mountain* and *Buffalo mountain*, in the north-

* The east end of which is in Carbon county, beyond the Lehigh river.

eastern corner of Perry county, gapped by the Susquehanna at Mt. Patrick and at Liverpool, are 7 and 8 miles long respectively, and unite in a slightly elevated knob on the east bank of the Juniata river a mile above Newport. Both of them have perfectly straight sharp crests, long gentle slopes inwards (into the cove), and outer terraces (that of Berry's facing south, that of Buffalo facing northwest,) distinct but not so strongly accentuated as those of Cove mountain, less deeply cut by ravines, and never separated from the mother mountain, for geological reasons to be hereafter explained.

Unlike the sharp ellipse of Cove mountain, that of Berry's mountain is gapped nearly to its base at its western end on the southern side, by a little stream descending into the Juniata. But a high divide behind the gap virtually closes the upper end of the cove.

It only remains to add, that on the eastern side of the Susquehanna river, Berry's mountain runs on through Dauphin county and returns as Peters' mountain (or Cove mountain). Buffalo mountain also reappears on the east bank of the river under the name of Mohontango mountain, and along its crest runs the north county line of Dauphin to the northwest corner of Schuylkill county.

As the Dauphin county anthracite coal basin is enclosed at its west end by the Cove mountain in Perry county, so in precisely similar style the west end of the Wiconisco anthracite coal basin is enclosed by Berry's and Buffalo mountains in Perry county.

This is the reason why the two coves resemble each other so closely in shape, size, and position; and it is also the reason why no anthracite or other workable coal measures now exist in Perry county, as will be more fully explained in another chapter.

Hill ranges.

While mountains surround Perry county on the north, west, and south, and penetrate it to a certain distance from the east, the space thus enclosed must be regarded, topographically, as an extensive wedge-shaped area of open country, traversed by many ranges of hills, which vary in

elevation from 200 to 500 feet above the drainage level, and are some of them cultivated in common with the valleys.

The arrangement of the greater number of these hills is remarkably complicated, but perfectly easy to comprehend with the aid of the colored geological map.

The arrangement of the others, forming a second class by themselves, and having nothing in common with the first class either in shape, size, or in rock composition, is on the the other hand quite simple, as the map shows.

Hills of No. VII (Oriskany.)

These consist of sandstone on one side and limestone on the other; the limestone rocks passing down under the sandstone, and commonly leaving the sandstone to form the main rib or crest of the hill, with a slope of shale.

The Lower Helderberg limestone No. VII being colored blue on the map, and the Oriskany sandstone No. VII yellow, the continuity of the hills of this class along its outcrop, zigzagging more than a dozen times over the county, is evident at a glance. However broken for a moment in its course by some stream, the hill range continues to mark the surface from township to township. However confused the landscape may appear to the traveler on the high road, or reviewing it from one of the hills of the range, it becomes at once reduced to an intelligible order when a neighboring mountain is ascended, and the broad expanse is looked down upon from above. The long lines of the zigzags are then seen fading away in the distance, or uniting in pairs or groups in the near foreground.

Occasionally the sandstone outcrops are so complicated as to constitute the bulk of the hill, and the limestone slopes sink in comparison into the valleys. In other cases the limestone rocks are so massive and repeated as to spread out into wider and higher hilltops, while the sandstone belt forms a selvage of lower elevation and minor importance. But the idea of a continuous range is never lost, and the union of the sandstone and limestone is indissoluble over the whole area, except along the extreme southern border of the county (at the foot of the Blue mountain approach-

ing the Susquehanna river) where the sandstone first and then the limestone ceases to exist, and the hill range necessarily disappears.

The map will show, also, that the zigzags of this hill-range (of the first class) correspond to or point towards the zigzags of the first, second, and third mountain ranges already described; and it will be shown in a subsequent chapter that the same geological causes operate to bring the two sets of zigzags into existence and into mutual concordance.

In describing the No. VI-VII range, it will be convenient to divide it into seven sections or courses, beginning at the north.

The first section, 8 miles long and perfectly straight and unbroken, forms the northern boundary of the county between the Juniata and Susquehanna rivers. The limestone faces the south. It is gapped by Cocalamus creek and another smaller stream.

The second section, 36 miles long, extends nearly the whole length of the county. It unites with the first section in a sharp point 2 miles west of the Susquehanna river; is straight for 8 miles to the Juniata river at Millerstown, with three gaps; then 5 miles further to Donnally's mills, where it is gapped by the south branch of Raccoon creek; and then 8 miles further (with another slight gap) as far as Ickesburg. Limestone always facing north.*

Here the limestone ends, or rather zigzags back three times. The sandstone begins to zigzag southward at a point 2 miles before reaching Ickesburg.

From a point 3 miles east of Ickesburg to New Germantown (15 miles) the course is straight, (with one zigzag half-way.) At New Germantown the limestone ends in a point. The sandstone points out 6 miles before reaching New Germantown, *i. e.*, opposite Andersonburg.

The third section, more than 30 miles long, measuring from New Germantown to the Juniata river below Baileys-

* It should be mentioned that though the range is here spoken of as a hill, yet along this part of its course almost no elevation can be seen, and consequently the "gaps" are quite insignificant.

burg, is known along its whole length by the local name of the Limestone ridge.

It is $2\frac{1}{2}$ miles broad north of Andersonburg and Centre, and between Centre and Sandy hill, where its belt of sandstone zigzags sharply several times.

For the next 14 miles it is a narrow, straight, and unbroken ridge. Zigzags twice opposite Bloomfield, and then runs on again, straight and unbroken, 8 miles further to the Juniata.

From a mile west of Bloomfield to the Juniata, a distance of 9 miles, the ridge has a double or triple crest of sandstone, inclosing a narrow stripe of limestone. In all other parts of its course the limestone forms its south face.

The fourth section, 16 miles long, returns sharply on the third, and close to it, from the Juniata river, past Bloomfield and Elliottsburg to Green Park, where the limestone (always facing north) points out. There are four gaps through it in Centre and Miller townships, but along a great part of its course there is no ridge, the ground is quite low, and the sandstone is rarely visible.

Four zigzags occupy the area ($2\frac{1}{2}$ miles wide from north to south) between Green Park and Landisburg, and there is a water gap through the first one a mile south of Elliottsburg.

The fifth section, 13 miles long, returns east for about 8 miles, and is known locally as *Iron ridge*. It is there cut out by the Perry county fault. The ridge is gapped by Richland run at the Perry furnace. A small outlier of sandstone and limestone occurs at Montebello narrows, 3 miles further east, brought up by the fault.

The sixth section, 10 miles long, with two sharp zigzags, is four times gapped, once by Sherman's creek a mile north-east of Oakgrove, where the ridge ends. Limestone always facing north.

The seventh section runs along the base of the Blue mountain, the limestone facing south. The sandstone and limestone grow less and less for 10 or 12 miles east of Oakgrove; and the ridge ceases to exist near Sterrett's gap.

Hills of No. VIII (Hamilton sandstone.)

The hills of the second class are confined to the eastern half of the county. They are of two kinds.

a. The first is a range of high, steep, chiefly monoclinical ridges, for the most part wood-clad and untilled, which enter the county from Juniata, three miles north of Millers-town, and range east almost to the Susquehanna, forming the county line under the name of *Turkey ridge*. Here, curving sharply round, it runs west-southwest, in a straight line, to the Juniata just below Millerstown, where its point is cut off by Cocalamus creek. Along this part of its course it bears the name of *Wild Cat ridge*. Several gaps have been cut through it, two by Cocalamus creek, and others by small unnamed streams on both the north and south courses. Rough and steep, it forms an encircling wall round the northeast and south of *Pfoutz's Valley*. Crossing the river it passes on under the name of *Raccoon ridge*, and four miles further is gapped at Donally's mill. Three miles beyond this point it swerves slightly to the southwest and continues for 6 miles to a point west of Roseburg, where, turning sharply, it zigzags back about 2 miles, resumes its former course, and runs to Sandy hill as *Bitman's Ridge*. In this part of the range it is gapped in four places. From Sandy hill it runs east-northeast for 4 miles, southwest for two miles, then turns sharply and ranges nearly east, past Mannsville and Bloomfield, to Inoculate run on the Newport-Bloomfield road, where a short turn to the southwest interrupts the line. Thence, immediately returning, it resumes its course to the Juniata river below Bailysburg. Here it bears the name *Buffalo hills*. Crossing the river it becomes *Half Falls mountain* and ranges to the Susquehanna, whence, immediately returning almost parallel with itself under the same name, it re-crosses the Juniata and sweeps west-southwest as *Mahanoy Ridge* to Little Germany, near which hamlet it comes to an end, as will be explained further on.

Reappearing a mile to the eastward as *Cranby hill*, it makes three short zigzags, forming the *Furnace hills*, and

dies down gradually to the level two miles northeast of the Blue Ball, near Landisburg.

A second ridge, distinct but very closely connected, diverges from Half Falls mountain (of which at its origin it forms part) and ranges across the Juniata for 5 or 6 miles as *Dick's hill*, steep on the northern but gentle on the southern slope. Two miles southeast of Bloomfield it zigzags suddenly, but almost immediately resumes its former course and (under the name of *Rock hill* and after crossing Sherman's creek, of *Pisgah hill*,) runs on southwest for about 8 miles till it terminates in this direction in a high knob near Oakgrove furnace. Curving round sharply at this point it sweeps in an almost straight line for nearly 20 miles, under the name of *Little mountain*, to the Susquehanna river at Marysville.

This sandstone range is a very conspicuous and important factor in the physical geography of the county, ranking in this respect only below the mountain range previously described. So much, however, will be found in other parts of this volume concerning it, that to add more here would be mere repetition.

Hills of No. VIII (Chemung.)

b. The second kind of hills included in this class are broader than the comparatively sharp-crested Hamilton sandstone ridges last described, and have flowing outlines of a gentle beauty. Innumerable runs and rills indent their flanks. Each rill descends from the central elevated rolling summit through a slight ravine, the sides of which are quite smooth and usually cultivated. The vista presented by miles of these ravines and intermediate rounded offsets of the range is most agreeable. The side of the ridge seems artificially ornamented for picturesque effect, scalloped or gophered in a wonderfully regular manner, and smoothed—almost polished—like a piece of furniture. The geologist will at once recognize the peculiar constitution of the ridge by this remarkable feature of its erosion, which demands and will receive a careful explanation further on in this report.

Five ranges of these hills in Perry county may be specified :

The first range commences at the Susquehanna river, in the northeast corner of the county, and runs for 25 miles to Roseburg in Saville township. It is perfectly straight for 16 miles, and then bends slightly more southward. It is cut in two by the Juniata river below Millerstown, and again by Buffalo creek 3 miles west of Markelsville. It is also cut, east of the Juniata, by the north branch of Wildcat run ; by two branches of Barger's run, coming from the north ; and the creek which enters the Susquehanna river at Liverpool.

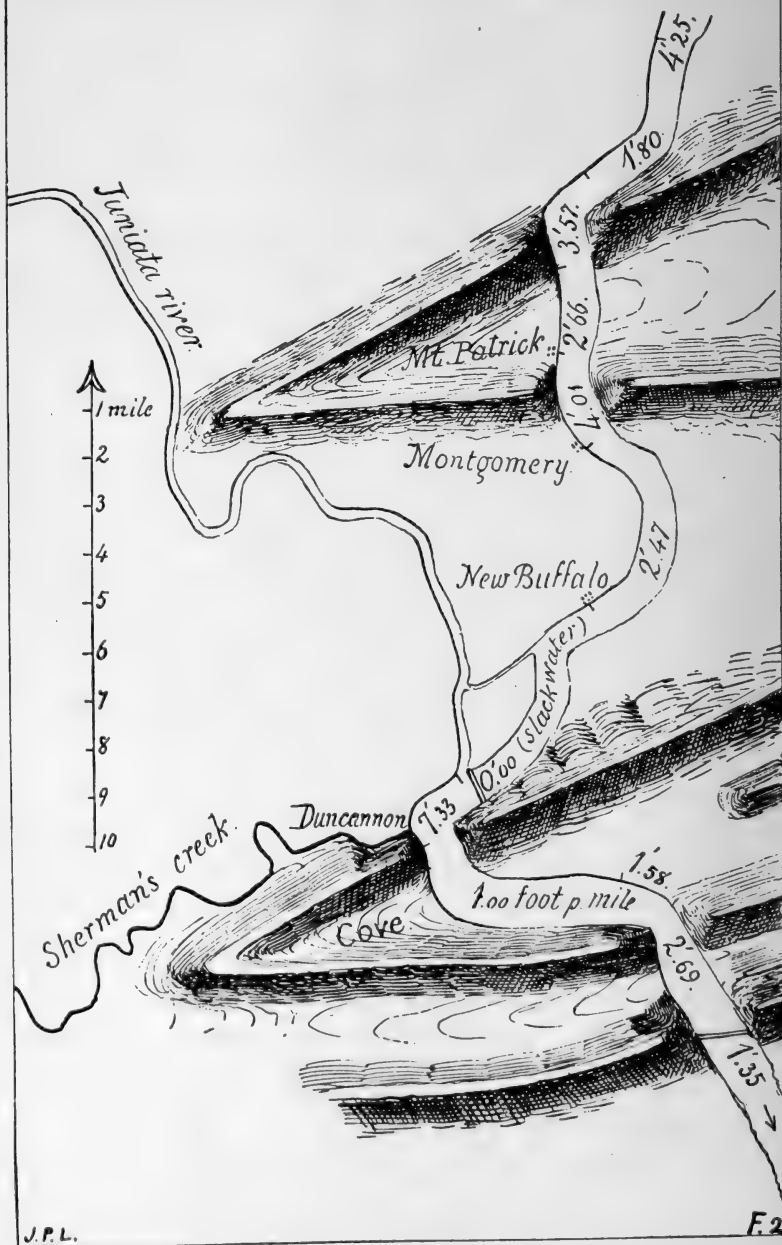
The second range runs straight for 20 miles as *Middle ridge* and *Middle Bucks Valley ridge*, from Roseburg back to the Susquehanna at Montgomery. It forms, with the first range, a solid mass of hill-land, east of Roseburg, around which Buffalo creek curls its headwaters in a semi-circle. It is unbroken by any water-course for 11 miles, from Roseburg to Newport, Little Buffalo creek flowing at its base the whole distance. The Juniata river gaps it at Newport ; bends north, and passes back through it 2 miles further on ; bends south, passes through it a third time one mile above Baileysburg. In the $5\frac{1}{2}$ miles of its course, between the Juniata and the Susquehanna, it is broken four times by three runs entering the former, and another entering the latter river.

The third range, short and irregular, is wedged in between Mahoning ridge and Dick's hill, west of the Juniata, 2 miles southeast of Bloomfield.

The fourth range, 20 miles long, starts at the Susquehanna river in the bend between Montgomery and New Buffalo ; is trenched transversely by the Juniata, and then by the Little Juniata ; is broken through successively by three of the northern branches of Sherman's creek, by Sherman's creek itself, and finally near its end by another branch. Two miles east of Oakgrove it curves sharply round to the south and east, and makes

The fifth range, 17 miles long, at the north foot of which
2 F^r.

The rate of water-fall in the Susquehanna R.



flows Fishing creek, passes Keystone and Marysville to the Susquehanna river.

Rivers, Creeks, and Runs.

The Susquehanna river flows in a shallow rocky channel, about half a mile wide, studded with islets, along the eastern border of the county, a distance of about 20 miles in a straight line, but of about 30 miles by its windings from north to south.

These windings are caused by the topographical obstacles which it encounters. Within three miles of the county corner it is deflected sharply westward along the north foot of Buffalo mountain, 3 miles to Liverpool, where it gets through the mountain by a boldly cut gap.

Cutting straight across the Hunter's run cove 3 miles, and issuing from a similar gap in Berry's mountain, it is deflected a little east around the end of Half Falls mountain.

Bending west again in a beautiful quadrant of a circle past New Buffalo, it encounters the Juniata coming in from the northwest. Here the two rivers have formed a plain or inland delta, 3 miles long by $1\frac{1}{2}$ miles wide, called *Duncan's island*, at the south end of which is the present confluence.

The combined waters, pressing against the north foot of Peter's mountain and flowing southwestward, gradually shave off its terraced slope, and then turn and flow through a gap into the Cove.

The river, flowing slantingly down and across the Cove, eastward, 5 miles, turns in through a gap in the Second mountain, and flows straight on to and through a gap in the Blue mountain into the Cumberland valley towards Harrisburg and Chesapeake bay.

The gradients of the Northern Central railroad, which descends its east bank, should give us the gradient of the Susquehanna river approximately, the height of rail above tide at Liverpool station being 396.11, and at Bridgeport depot 354.57, equal to a fall of about 40 feet in about 22 miles, =1.82 feet per mile.*

* See Report of Progress, N, table 110, pages 115 and 111, pages 116, 117.

The canals and pools along the Susquehanna, however, determine its real rate of descent as follows:

A. Locks.	B. Miles.	C. Feet.
Mahantango lock,	35.6	410.97
Dry Saw-Mill lock,	33.8	403.32
Liverpool upper lock,	30.8	397.92
Liverpool lower lock,	29.0	391.49
Mt. Patrick lock,	26.4	384.57
Montgomery lock,	24.7	377.75
Buffalo lock,	21.6	370.10
Juniata Junction lock,	17.0	370.35
Raisner's lock,	—	362.09
Clark's Ferry guard-lock,	15.0	356.09
Twin Tavern lock,	12.0	343.09
Dauphin lock,	7.7	336.29
Rockville lock,	5.1	329.30
Harrisburg lock,	0.0	322.39

A is the tabular list of locks descending the river.

B gives the distance, *in miles*, from Harrisburg.

C gives the *elevation above tide of the water in the dam above each lock, in feet*, according to Allen and Ames' survey, 1877, as explained in the prefatory note to table 115, page 120, of Report of Progress N.

From Mahantango, at the northeast corner of Perry county, to Rockville, at the southeast corner of the county, a distance of $30\frac{1}{2}$ miles, the Susquehanna river has a total fall of $81\frac{1}{2}$ feet, or at the rate of about $2\frac{3}{8}$ feet per mile.

From.	To.	Miles.	Fall.	Rate per mile.
Mahantango—Dry Saw-Mill,		1.8	7.65'	4.25'
Dry Saw-Mill—Liverpool U. L.,		3.0	5.40'	1.80'
Liverpool U. L.—Liverpool L. L.,		1.8	6.43'	3.57'
Liverpool L. L.—Mt. Patrick,		2.6	6.92'	2.66'
Mt. Patrick—Montgomery,		1.7	6.82'	4.01'
Montgomery—Buffalo,		3.1	7.65'	2.47'
Buffalo—Juniata Junction,		4.6	0.00'	0.00'
Juniata Junction—Clark's Ferry,		2.0	14.26'	7.13'
Clark's Ferry—Twin Tavern,		3.0	3.00'	1.00'
Twin Tavern—Dauphin,		4.3	6.80'	1.58'
Dauphin—Rockville,		2.6	6.99'	2.69'
Rockville—Harrisburg,		5.1	6.91'	1.35'

The Susquehanna river, then, descends with comparative rapidity where it passes through the five gaps of Buffalo, Berry's, Peters', Second, and North mountains, and less

rapidly where it crosses the intermediate valleys. Behind or north of each mountain it is dammed back upon the softer rocks, and descends over the hard rock-ledges in the gap as over a natural wier.

For example, its rate *behind* the Buffalo mountain is 1.80', but in the gap itself 3.57'.

Behind Berry's mountain its rate is 2.66', but in the gap itself 4.01'.

Behind Peters' mountain its bed is almost a dead level for four miles, and then falls in the gap at the rate of 7.13'.

Across the Cove its rate is only 1.00' and 1.58', but through the Second mountain and Blue mountain gaps it averages 2.69'.

Hence to Harrisburg the rate is 1.35'.

It is plain to see that the ribs of sandstone rock which form the several mountain crests and descend steeply (sometimes vertically) to and across the bed of the river in the several gaps, form natural dams (and must have always formed natural dams) over which the river has been tumbling for ages. These natural dams, being still in process of destruction, must have been higher above ocean level in each preceding age as we follow the process of wear and tear backwards in the order of time.

It follows that the river, as a whole, must have *once* flowed on a level with what is *now* the tops of the mountains.

But it does not follow that the relative heights of the mountains and valleys were the same then which they are now, and that the whole country behind the Blue mountain was then flooded by the river; in other words, that all central Pennsylvania was then a great lake. On the contrary, what is true of the Susquehanna is true as we shall see of the Juniata and all its other main branches, and of all their secondary branches, and of all the creeks and runs and rills which feed these secondary branches with water; for the whole surface of the country must have shared in the gradual lowering of the bed of the Susquehanna.

But if this be true, then the entire surface of the country must have stood higher and higher above sea level as we go back in time: not the valleys only, but the mountains also;

for the hard-rock outcrops must always have stood higher than the soft-rock outcrops. And thus we can easily imagine both the mountains and the valleys of the surface of Perry county in past times standing at an elevation several thousand feet higher above sea level than now; and not of Perry county only, but of all Pennsylvania, and in fine of all the Appalachian belt of the United States.

The Susquehanna river has therefore a *rock bed* its whole length past Perry county, the edges of the strata (upturned sometimes towards the north, sometimes towards the south) crossing it from bank to bank, and producing riffles in many places, behind which lie shallow sheets of river pebbles and river sand, brought down from the northern counties, and from the State of New York,—pebbles moved forward by the spring and fall freshets and replaced by others,—pebbles gradually being ground into mud, and to be finally spread upon the bottom of Chesapeake bay and the Atlantic ocean. The Duncan's island flat is an inland delta of such deposits.

In long-continued droughts the river bed is left uncovered in a thousand places, and the bordering strata can be traced across it, or even used for fording. After heavy general rains, or after the melting of the winter snows, a sea of water descends the broad channel, filling it to the top of its banks; and débâcles of floating ice threaten the safety of the railroad and canal which accompany its course. Millions of tons of rounded stones and sand are poured into it by all its affluents, keeping up its supply of grinding material for lowering its own bed, and furnishing the amplest evidence that could be desired of the continuous destruction of the whole country and the continuous lowering of the general surface through all ages.*

The Juniata river is the principal branch of the Susquehanna in central Pennsylvania, as it drains the face of the Allegheny mountain for a length of 50 miles, and also por-

* Too much has not here been said on this subject to prepare the reader for the important geological consequences of this process of river erosion, a good understanding of which is absolutely necessary, if the descriptive geology of this or any other county of Pennsylvania is to be adequately comprehended.

tions of Blair, Huntingdon, Mifflin, and Juniata counties before entering Perry county around the east end of Tuscarora mountain, 2 miles above Millerstown.

It flows nearly straight across the county (past the west end of Buffalo mountain) 5 miles to Newport. It then makes a letter S ($3\frac{1}{2}$ miles) to Bailsburg; followed by a bend to the south, through the little gap of Half Falls mountain, $1\frac{1}{2}$ miles; and then flows straight 5 miles further to the Susquehanna river junction.

From Millerstown to the Aqueduct, measured along the track of the Pennsylvania railroad, the distance is 15 miles; and the total descent of the railroad grade in this distance is 31 feet; an average rate of about 2 feet to the mile; thus:—

Millerstown, (138 miles from Philadelphia,)	408' A. T.*
Newport, (133 ")	395'
Baily's, (128 ")	387'
Aqueduct, (123 ")	377'

The old levels of the Juniata division of the Pennsylvania canal † makes the water-fall 30.6 feet; the surface of the Millerstown dam being stated at 388' and the miter-sill at the Junction 357.3'. But as the water above the lock at the Junction is 370.35', and the water in the Juniata river under the aqueduct, stood at 342.6 when the survey of 1877 was made, ‡ (or 340.6 by another survey, §) the actual fall of the bed of the river is probably something more than 31 feet.

The rate of descent must be much more uniform than in the case of the Susquehanna river, because the Juniata river passes through only two gaps in hard rock, and these are very small, viz: one through the limestone-sandstone range at Millerstown, and the other through the same range at Bailsburg. Everywhere else it traverses broad belts of comparatively soft strata. The influence of the geology upon a river course is however as well exemplified in the case of the Juniata as in that of the Susquehanna; for the sigmoid curve which the Juniata makes between Newport and Bailsburg

* See Report of Progress N, table 1, page 3.

† See table 113, page N, 119.

‡ Table 115, page N, 121.

§ Table 125, page N, 136.

is evidently due in part to the ridge below Newport, and to the effort of the drainage waters to get round its eastern end.

Sherman's creek plays the principal rôle in the drainage of Perry county, and is wholly confined to the county; heading in its westernmost township (Toboyne,) and flowing eastward through Jackson, Madison, Tyrone, Spring, Carroll, and Wheatfield to the Susquehanna river at Duncannon, two miles below the mouth of the Juniata river.

In its exceedingly tortuous course past the villages Fairview, New Germantown, Mt. Pleasant, Beavertown, Centre, Landisburg, Bridgeport, Shermansdale, and Delville, it receives a hundred smaller streams, of which the principal are *Brown's* run, *Houston's* run, *Laurel* run, and *McCabe's* run, descending from the western mountain spurs, and *Anderson's* and *Montour's* runs coming in from the north, the one past Andersonburg and the other past Elliottsburg.

Sherman's creek illustrates the geology of Perry county in two ways:

First, It occupies itself solely and wholly with collecting and transporting eastward the rainwater which falls upon the area lying to the south and west of the blue limestone zigzags.

A mile below Bridgeport, it breaks through the Limestone ridge, and flows forward (still eastward) across the brown into the pink belt, and along the north face of the North Cove or Peters' mountain to the Susquehanna.

Why, when it had reached Shermansdale, it did not adopt for its channel the straight and narrow valley lying open before it, between the Cove and Blue mountains (past Grierspoint, Keystone, and Fenwick) instead of *receiving a branch* from that direction, and *itself turning back* to take a longer, crookeder, and more round-about northerly way to its destination, will be explained when the local geology of Carroll township is described.

But why Sherman's creek makes its bold curve from Fairview to Bridgeport is perfectly well explained by the coloring on the map, where the stream is seen cutting

through the ends of seven different spurs from the mountains on the west.

Secondly, Sherman's creek, in flowing from the west eastward, shows plainly *the general slope of the formations, towards the deep coal basins of Schuylkill county.** And in this tendency towards that profound geological depression in the earth's crust, it is imitated by the other large drainage-ways of the county: by Little Juniata creek, by Little Buffalo creek, by Buffalo creek, and by Raccoon run all of which make towards the anthracite coal basins, and would have been branches of the Schuylkill river had they not been stopped by the Juniata and Susquehanna rivers.

Little Juniata creek heads on the west township line of Centre, $2\frac{1}{4}$ miles east of Elliottsburg, and drains (eastward) the long narrow valley south of Mahanoy ridge for 8 miles. Issuing through Dick's ridge southward, it flows into the Susquehanna at Duncannon, $1\frac{1}{2}$ miles below the mouth of its great namesake the Juniata river. That it did not keep straight on, *north of Dick's hill*, to the Juniata river is one of those eccentricities of drainage for which a local and not very apparent geological cause must be sought.

Little Buffalo creek, heading $1\frac{1}{2}$ miles west of Mannsville, drains (eastward) the corresponding valley north of Limestone ridge, and enters the Juniata at Newport. It is 10 miles long.

Buffalo creek, with its numerous branches, drains all Salville and Juniata townships, and enters the Juniata river a mile above Newport.

For 8 miles west of the river, it meanders down the center line of the great trough in which lies the Wiconisco anthracite coal basin. It thus illustrates the geology of Perry county, just as Sherman's creek does in flowing down the middle of the Dauphin county coal basin.

The extreme head-waters of its northern branch are at

*Landisburg, at the mouth of Montour run, is 740' above tide, (table 203, page 228, N,) and railroad grade at Duncannon at the mouth of Sherman's run is 376', (table 125, page 136, N.) The distance in a bee-line is 11 miles. Therefore, the descent eastward must be at an average rate of $364' \div 11 = 33'$ per mile, although by the course of the creek it is only $364' \div 25 \pm$ miles = $14'$ per mile, or less, as Landisburg is considerably above the creek.

the county line, between Tuscarora and Conecocheague mountains, 8 miles west of Ickesburg. Another branch issues from the little cove in the heart of the Tuscarora mountain, and flows south past Ickesburg to the main creek, $\frac{1}{2}$ mile below Roseburg. A third branch, from the south, encircles the Roseburg hills, heading where Little Buffalo creek heads, west of Mannsville. The rest are insignificant. Its whole length (in a straight line across the map) is 19 miles, but its windings double the distance.

Raccoon run drains for 10 miles Raccoon valley at the foot of Tuscarora mountain, with the limestone ridge on its right (through which it receives a little branch at Donnelly's mills) all the way to the Juniata half a mile below Millerstown.

Fishing Creek run drains for 8 miles the valley between the Blue and Second mountains, past Keystone and Fenwick, and enters the Susquehanna below Marysport.

Cove creek, 4 miles long, drains the Cove into the Susquehanna a mile below Duncannon.

Hunter's run, 5 miles long, drains the Berry-Buffalo mountain cove into the Susquehanna at Mt. Patrick.

Barger's run, 5 miles long, drains most of Liverpool township into the Susquehanna just below Liverpool.

Wild Cat run locks its head branches (around Liberty Hall) into those of Barger's run, and drains the south half of Greenwood township into the Juniata half-way between Millerstown and Newport.

Cocalamus creek is a large and important stream entering Perry county from Juniata county through a little gap in the sandstone and limestone ridges 3 miles north of Millers-town. It flows around the foot hills at the east end of Tuscarora mountain, and joins the Juniata river a mile below Millerstown.

Other smaller runs, draining the country between the two rivers, are too numerous to merit special description.

The Valleys of Perry county.

It is always a source of embarrassment to a geologist, when called upon to describe an area bounded by artificially ar-

ranged straight lines, that these are pretty sure to cut across the outcrops of the formations. But the difficulty of describing a "valley" is equally great; for what the geologist calls a valley is not in all cases what the inhabitants of it will accept.

Sometimes indeed the geological valley coincides with the course of the stream through which it flows; as in the case of Raccoon valley, Little Buffalo valley, Hunter's Run cove, and Allen's cove in the eastern part of Perry county, Horse valley, Little Illinois valley, and Houston's valley in the western part, and Shaeffer valley and Kennedy Run valley in the south.

In other cases the geological valley is occupied by several streams, sometimes flowing in opposite directions; as in the case of Fishing Creek valley, one half of which is drained eastward into the Susquehanna at Marysville, the other by a branch of Sherman's creek westward to Shermansdale; and in the case of Liverpool valley, one half of which is drained by Barger's run eastward, and the other half by Wild Cat run westward.

Even Little Buffalo Creek valley has its western part drained in an opposite direction (westward) by Buffalo creek; and Raccoon valley has its western third drained by branches of Sherman's creek; and Little Juniata Creek valley has its western end drained (westward) by another branch of Sherman's creek.

Sherman's valley is a notable instance of the *looseness* with which the term "valley" is applied in *geography*, as opposed to the *strictness* with which the term must be used in *descriptive geology*. For, by "Sherman's valley" is popularly understood not only the open country from Shermansdale to Duncannon through which the lower part of this fine stream meanders, but also the open country from Bridgeport all the way to the west end of the county through which the stream flows in its middle and upper courses. But these two open countries have wholly different geological characters, and are separated entirely from one another by a ridge, through which the stream breaks, leaving the one and entering the other; that is, forsaking one *geological*

valley to flow through another of an entirely different character.

The easiest way to overcome the difficulty is to speak of the *lower* Sherman's valley and the *upper* Sherman's valley; but as the name was first given to the stream at its mouth, it should be reserved for the lower valley through which it flows, *i. e.*, from Shermansdale down. But then it becomes very hard to find a name or names for the upper parts of its course.

Still more difficult it is for the geologist to use such terms as "Juniata Valley" and "Susquehanna Valley," which mean in ordinary language merely the farming country bordering the Juniata or the Susquehanna river, whether confined to narrow meadows inclosed between cliffs or expanded into side valleys running back into the country.

In fact, to the descriptive geologist a great *river channel* cutting across the outcrops of a country is no *valley* in the proper sense of the term, but merely a local accident of the true valleys of the country, which *geologically* pass across it, without regarding it or being influenced by it at all.

Thus Sherman's valley, really, *i. e.*, geologically, includes Duncan's island and New Buffalo, and runs on north of Peter's mountain far into Dauphin county.

Thus also Buffalo and Little Buffalo valleys are *geologically* one and the same; uniting in a curve around the west end of the Roseburg hills, and passing on eastward *across* the Juniata river and *across* the Susquehanna river, as if these had no existence, into Dauphin county beyond Liverpool and beyond Montgomery.

Instead then of describing valleys under their *popular* or *local* names, the geologist is obliged to describe them under the *names of the soft formations* along the outcrop belts of which they have been eroded or excavated, and to limit them by their geological boundaries, viz: The hard rock outcrop ridges.

But there is still another way.

Valleys* are distinguished by geologists as of three classes according to their internal structure, that is, *monoclinical*,

* That is such valleys as concern a report on Perry county.

when their rocks all dip one way ; *anticlinal*, when their rocks plunge from the center line of the valley in opposite directions toward and under the bounding ridges ; *synclinal*, when their rocks slope in from the sidehills towards the centre line of the valley.

The *monoclinal* valleys of Perry county are such as Raccoon valley, Little Buffalo creek valley, Wildcat creek and Barger's run valley, Little Juniata creek valley above and below Montebello narrows, Sherman's valley from 5 miles west of Delville down, the Grier's Point-Keystone-Henwick valley south of Little mountain, and Polecat valley.

There are four *anticlinal* valleys in Perry county—Horse valley at its west end, Pfoutz's valley in the northeast, Bloomfield valley in the middle, and the Little Bridgeport valley in the southwest.

The *synclinal* valleys of Perry county are those through which Upper Sherman's creek, Brown's run, Houston's run, Laurel run, McCabe's run, and Green run descend between anticlinal mountain spurs ; and those through which the lower part of Buffalo creek, the lower part of Sherman's creek, Cove run, and Hunter's run flow to their mouths. All these streams flow eastward along troughs tilted up at their western ends, as water which falls upon the forecastle of a ship necessarily flows aft into the waist.

The two great synclinals of Perry County.

Fig. 1.

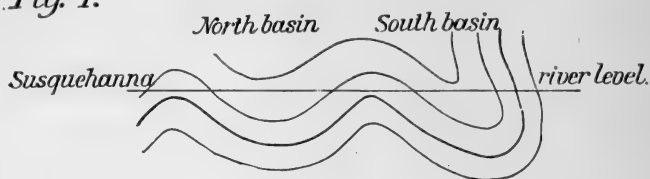


Fig. 2.

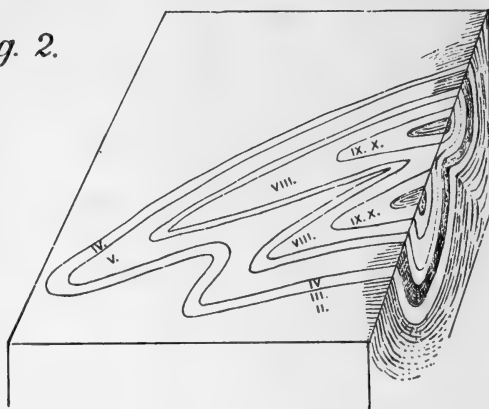


Fig. 3.

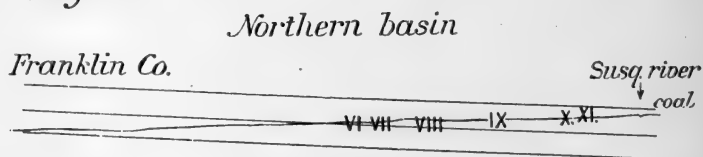


Fig. 4.

Southern basin.



CHAPTER II.

The geological structure of Perry county.

Viewed as a whole the geological structure of Perry county is the simplest possible :—about 30,000 * feet of Palæozoic measures, thrown into *two great troughs* separated by *one great arch*.

The *northern trough* extends the whole length of the county, passing out south-westward into Franklin county.

The *southern trough* extends half its length, passing out south-westward into Cumberland county.

The centre line of the northern trough crosses the Susquehanna river a mile north of Mt. Patrick ; the Juniata river two miles north of Newport ; and passes through the villages of Juniata, Markelsville, Roseburg, Sandy Hill, New Germantown, and Fairview in Toboyne township.

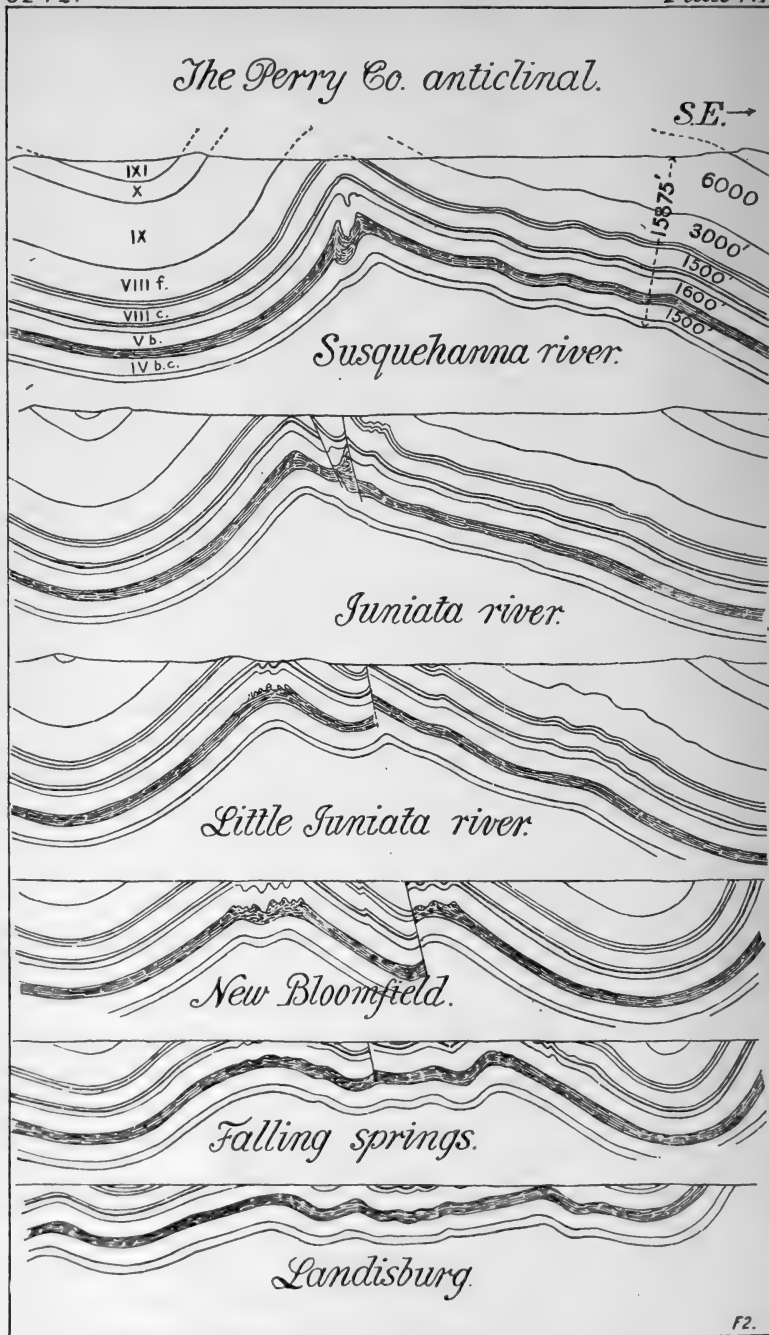
The center line of the southern trough crosses the Susquehanna river $1\frac{1}{2}$ miles below Duncannon ; and passes half a mile north of Shermansdale and through Oakgrove in Spring township.

The northern trough extended eastward becomes the Wiconisco anthracite coal basin of Dauphin and the Pottsville basin of Schuylkill county.

The southern trough extended eastward becomes the Dauphin county coal basin, which unites with the Wiconisco basin at Trevorton, in Schuylkill county.

Both troughs are very deep (equally deep) at the Susquehanna river ; and shoal up westward ; but not at the same rate. For, while the bottoms of the troughs are exactly on a level with each other at the Susquehanna and also at the distance of 8 miles west of it, that of the *southern trough* rises in the next 12 miles as much as that of the

* That is, counting only the formations which appear at the surface in Perry county.



northern trough in the next 36 miles; or exactly three times as fast.

The cause of this difference is seen in the fact that the *two sides of the northern trough* are symmetrical; whereas the *south side of the southern trough* is turned up and pressed over inwards; narrowing, sharpening and shortening the trough all at the same time and by the same operation. See page plate III, page 30, Figs. 1, 2, 3, 4.

Sub-plications of the troughs and arches.

The structure however, is by no means so simple as the foregoing general idealized sketch would lead the reader to suppose, except along the Susquehanna river, the eastern border of the county, and for a few miles inland to the west. After that it becomes complicated by many exceptional details, which are, each of them, of great local importance, and which it will be the business of this report to describe. Meanwhile, a general idea of these complications must here be given.

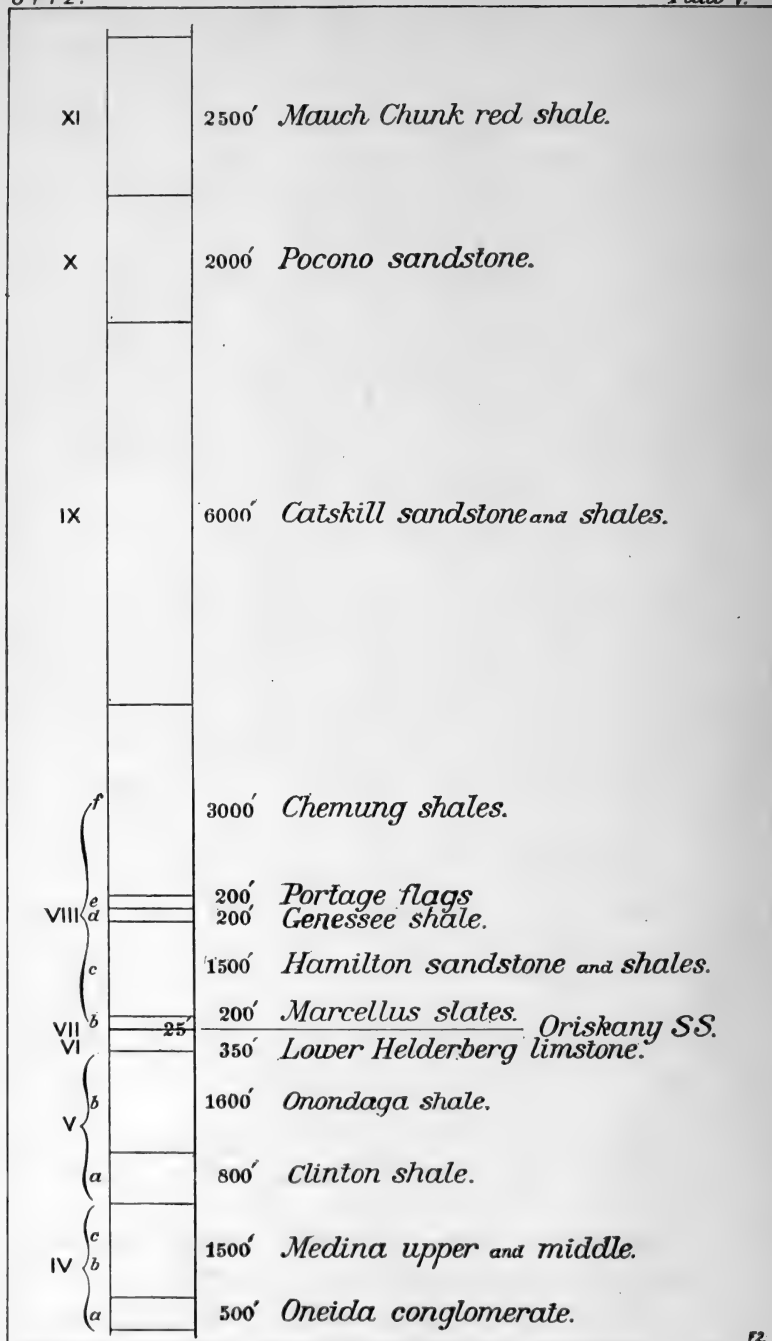
Along the Susquehanna river there are but *two great troughs*, each simple in its structure, and *one great arch* between them (represented by Half Falls mountain, 1 mile south of Montgomery,) itself also quite simple in its structure.

On the Juniata river the northern trough still retains its simplicity, but the *middle arch* (or grand anticlinal) at Baileysburg begins to exhibit irregularities, being both double and faulted.

Nine miles west of the Juniata, on a line through Bloomfield, the *middle arch* is not only complicated three times on each side of its included little basin, but also faulted. See page plate IV, page 32, Fig. 1.

Three miles west of Bloomfield, the little basin has become enlarged by the absorption of some of the plications on the north side of it, and by the introduction of new rolls See Fig. 2.

Five miles further west, a cross-section from Green Park to Bridgeport and Oakgrove shows the little basin complicated four times, as in Fig. 3.



Five miles west of Green Park, a cross-section through Centre Village shows that the *southern trough* has passed out of Perry county into Cumberland, as also the axis and southern half of the middle arch. See Fig. 4.

Six miles west of Centre Village, a section of the *north-ern trough* through Beavertown restores it to its original simplicity. See Fig. 5.

Ten miles west of Beavertown, the southern half of the great anticlinal is magnificently plicated. See Fig. 6.

However simple then may be the general structure of Perry county, its complications in detail are numerous and very important, causing many local repetitions of the outcrop of each rock, and giving a curious and beautiful zigzag pattern to the colored geological map.

Faults.

While the two great troughs have bent to all appearance without breaking, the intermediate great arch suffered not only numerous plications, but at least three important fractures, one of which is sixteen miles long. But, as the character of these *up-throw faults* can not be understood without a knowledge of the rock-formations affected by them, their description is postponed to a following chapter, Chapter IV.

Geological history of the district.

At the earliest date to which Geology can point back with tolerable certainty in the history of what is now Perry county, the interior of the North American Continent was an ocean of unknown extent into which were borne the sand and mud of neighboring lands, swept down by the rivers of that distant age to make the beds of rock which to-day compose the solid land of the United States.

The history of this process is written in the rocks, and a brief sketch of the history is essential to the intelligent perusal of this report.

In the following table are given the names of the different formations which, lying one upon another, are composed of the sediment washed at different dates into this

ancient ocean of North America. The lowest is the first deposited—the oldest—and the others were laid down successively above it.

The uppermost formations, Nos. XII and XIII, have been, in the course of ages, swept away from Perry county, but remain in the counties east of the Susquehanna river.

The lowermost formations, No. I and most of No. II, are everywhere buried underground in Perry county, but come to the surface in Cumberland and Franklin counties.

Table of Palæozoic rocks, with their thicknesses as exposed in Perry and bordering counties.

	No.	Name.	Thickness.	Composition.
Carboniferous.	XIII.	Coal Measures,	2500'	Sandstone, shale, and coal.
	XII.	Pottsville,	1000'	Pebbles and sandstone.
	XI.	Mauch Chunk,	2500'	Red shale.
	X.	Pocono,	2000'	Gray sandstone.
Devonian.	IX.	Catskill,	6000'	Red sandstone and shale.
	VIII.	Chemung,	3000'	Olive sandstone and shale.
		Portage,	200'	Shale.
		Genessee,	200'	Dark shale.
		Hamilton,	1500'	Shale and sandstone.
		Marcellus,	200'	Dark shale and limestone.
		(Upper Helderberg, absent.)		
	VII.	(Cauda-galli,)	absent.)	
Upper Silurian.		Oriskany,	25'	Sandstone.
	VI.	Lower Helderberg, . . .	200'	Limestone and shale.
	V.	Onondaga,	1600'	Shale.
		Clinton,	800'	Red sandstone and green shale.
	IV.	Medina,	1500'	Sandstone and shales.
Lower Silurian.		Oneida,	500'	Conglomerate and sandstone.
	III.	Hudson River,	1000'	Slates and shales.
		Utica,	500'	Dark shales.
		Trenton,	500'	Limestone.
	II.	Chazy,	5000'	
	Calceiferous,			
Cambrian.	I.	Potsdam,	2000'	Sandstone and slate.
Total,			32725'	

All the formations vary greatly in thickness in different counties, and even in different parts of a county; and in some places were not deposited at all; so that the thicknesses assigned to them in the table must not be taken as exactly correct, but only as general indications. No. I, for example, is several thousand feet thick in the mountains south of

Carlisle and Chambersburg. No. II is more than 6000 feet thick in Blair county, but may not be 3000 feet thick at Harrisburg and Carlisle. No. III is more than 5000 feet thick on the Lehigh and Delaware rivers, but less than 1000 feet thick in Bedford county, And so with the other formations.

It appears then that more than six miles of material accumulated in middle Pennsylvania while it was the bed of a sea ; so that in places where these rocks exist in full thickness a bore-hole would have to be sunk to that depth to reach the azoic rocks on which they lie.

Changes in the depth of the sea seem to have taken place at certain stages in the long history of the palæozoic deposits. Either different parts of the sea filled up with unequal rapidity ; or its bed settled unequally ; or slight upward movements of the crust of the earth took place along certain lines or at certain points, so as to expose parts of the sea bottom to the air for short times, during which there could be no deposits at such places. But in spite of these irregularities, it is evident that there was an almost continuous subsidence of the crust of the earth beneath the palæozoic sea from first to last ; for, otherwise there could not have been a series of formations six miles thick deposited. The interruptions in the process were local, and resulted in the loss of only a few hundred feet of rock measures. At such places there must have been islands or sand-banks in the sea, like the one at Marysville, described in the report on Rye township ; and another may be indicated by the Bridgeport sandstone in the western part of the county.

By whatever cause such changes in the condition of the palæozoic column may have been produced, they seem to have had an important effect upon the animal life which prevailed in the sea in different ages, changing their conditions of existence, causing some species to perish or migrate to distant regions, and bringing in others to occupy their places. In some cases it seems to have happened that species driven away for a time afterwards returned. The genus *Renssæleria*, for example, disappears from the rocks at the top of the Oriskany sandstone (No. VII.) but ap-

pears again higher up in the Hamilton sandstone (No. VIII g.)*

As the eastern part of the sea seems to have sunken to much greater depths than the western parts, the eastern deposits in middle Pennsylvania were both coarser and thicker than those in western Pennsylvania, Ohio, and the western States, and contain a much larger proportion of gravel beds, sandstones and shales to limestones, except at the bottom of the whole series (No. II.)

Towards the close of the palæozoic age the bed of the sea seems to have remained stationary and become filled nearly to water level, producing continental swamps and islands of carboniferous vegetation, resulting in the production of the Coal Measures. A further subsidence however allowed the deposit of an additional thousand feet of Permian strata, before the great change came which elevated the continent, drained away the sea waters to other regions of the earth's surface, and established a new order of events.

This change was brought about by a great pressure from the direction of the present Atlantic seaboard, which thrust the thick formations of Middle Pennsylvania sideways, folding them together, elevating them into arches and depressing them in troughs.

As soon as this state of things commenced the frosts and rains began to wear away the new continent, and a great river system was established which began its work of transferring the waste of the land into the Atlantic ocean. This river system is essentially that which is represented on our maps. It has been at work through all ages since the close of the coal era. The continent has never since then been submerged, at least for any length of time sufficiently long to allow of the deposit of additional ocean sediments.

The waste of the continent during the Triassic, Jurassic, Cretaceous, and Tertiary ages has of course been enor-

* Since this chapter was written, I have received the first volume of the Geological Survey of Wisconsin. It may be merely a coincidence, but is worth remark that a dry area existed over that State during the same period, from the Lower Helderberg to the Hamilton. There is consequently a gap in the geological history of Wisconsin almost exactly coincident with that here alluded to in Perry county.

mously great ; and there is no part of the earth's surface where the erosion of the rocks can be better studied, or the quantity of material can be more easily estimated. (See the numerous cross-sections given in this report.)

To adduce a single instance :—The floor of Horse valley is made by the exposed outcrops of limestone No. II. On each side of the limestone descend in opposite directions the slates of No. III. These once arched over the limestones, but have been worn away. Tuscarora mountain and Conecocheague mountain on each side of the valley are made by the sandstones of No. IV, which once arched over the slates of No. III. The still higher formations from No. V to No. XIII (the Coal Measures) once lay in successive arches over No. IV. In other words there was once a pile of formations say 25,000 feet (nearly five miles) thick arching over what is now Horse valley, all of which has been eroded and carried away in the lapse of geological time.

The same is true of all parts of Perry county, with the difference that in the troughs there has been less erosion than on the rolls. For example, in the Cove, most of the formations are still preserved under ground, and only say 5000 feet, or about a mile of rocks, have been removed.

If then we take 3000 yards as the average thickness of rocks removed from Perry county, and multiply it by the area of the county, say 350,000 acres, or about 1,700,000,000 square yards, we get a quantity of over 5,000,000,000,000 cubic yards of rock washed away into the Atlantic.

But very few people have any idea of the amount of work done by a single river like the Juniata in transporting the land into the sea.

In ordinary weather, a gallon of Juniata water carries about 8 grains of earthy sediment, or one pound for every 100 cubic feet of water.

At Millerstown, the river is about 600 feet wide and 4 feet deep, with a current flowing about 2 miles an hour ; that is, 24,000,000 cubic feet of water pass Millerstown every hour, carrying 240,000 pounds (120 tons) of rock sediment. In other words, 1,000,000 cubic yards of the rock waste of Juniata, Mifflin, Huntingdon, and Blair counties pass

through Perry county down the Juniata river to the sea every year. The water basin from which this river sediment comes measures about 10,000,000,000 square yards. Its average loss *per year* is, therefore, about the *ten thousandth of a yard*. If we take into account the gravel and stones rolled down the river in flood times, and carried down by ice, it will be safe to call it the *five thousandth of a yard*.

The whole surface of the Juniata country has, therefore, been lowered say *one foot* in 1500 years, or 3000 yards in 13,500,000 years; that is, supposing the climate was always the same, and the Juniata river never did more work than it does now. But as there is every reason for believing that the erosion in the earlier ages was much more violent, and the river far more a torrent, the time required to account for the erosion of the country may reasonably be reduced to ten or even five millions of years, a length of time justified by the vast deposits of the Triassic, Jurassic, Cretaceous, and Tertiary ages.

It is this erosion which has revealed so grandly and beautifully the internal structure of Perry county, showing the arches and troughs into which the formations have been pressed, and making the present mountains and ridges out of the edges of the harder, and the valleys out of the edges of the softer formations, as will be amply explained in the course of this report.

The folding of the rocks of Perry county has been so great as to leave scarcely any of them in their original horizontal position. Almost all the strata where they appear at the surface are uptilted at various angles, often very steeply. Some of the folds are so large as to be several miles across; but most of them are so small as to be measured by hundreds of yards or feet; and there are multitudes of still smaller rolls which affect the working of quarries and ore mines. But they all belong to one general system, and are to be explained in the same manner, namely: by a thrust of the whole country from southeast northwestward.

The extent of this thrust can be calculated by taking a cross-section of the country (say along the line A B on the

map) from the Tuscarora mountain to the North or Blue mountain, a distance of 18 miles, and smoothing out the rolls to their original plane.* The horizontal section measures about 30 miles. The loss of breadth by crumpling is, therefore, 12 miles in 30; i. e. 40 per cent.

Supposing this rate to hold good for the whole palæozoic belt of middle Pennsylvania from the South mountains to the Allegheny mountain, a cross distance of about 65 miles, we get an original horizontal breadth of deposits equal to about 110 miles; which means a movement of the South mountain line of country inland (or northwestward) for a distance of 45 miles, or nearly three times the width of Perry county.

This is not the place to discuss the probable causes of such a movement, but only to state the fact, which is illustrated moreover in several other ways, (1) by cracks or faults in the formations; (2) by marks on the contact faces of the layers of rock, called "slickensides," grooved and polished surfaces, produced by friction under great pressure; (3) by the disjointed condition of limestone beds bent into semicircles, as at Ayl's and Baird's quarries near Bloomfield; and (4) by the distortion of fossil forms in the rocks, showing how the universal movement of the mass in which they are imbedded has squeezed, bent, and twisted them out of shape. A large part of the fossils of Perry county are almost useless to the palæontologist, and he is compelled to piece them together and compare them with similar specimens from other regions where the pressure has been less intense or the stone less plastic.

The great thickness of middle palæozoic formations, and their crumpled condition as above described, makes the classification of the fossils in their proper places in the series as difficult as it is interesting. The series of formations from the *Mauch Chunk red shale* (No. XI) in the coves down to the *Utica shale* (No. IIIa) in Horse valley are more or less completely exposed to view. Some of these formations abound in fossil forms, others are exceedingly barren

* See this method applied to one of the anthracite coal basins in Report AA, 1883.

of them. Exposures of the Devonian shales and sandstones are ample and numerous; exposures of the Utica shale for example on the other hand are few and scanty; but on the whole no county in the State presents a more instructive field to the palæontologist.

CHAPTER III.

Description of the Formations.

No. III. Utica and Hudson River shales.

These shales make but small appearance in the county. They are limited to a few spots on the west county line and to the northwest corner, Horse Valley, where the Utica shales surround its middle and most deeply eroded portion. They are here exposed by the erosion of the Horse valley and West Tuscarora anticlines, which are deeply eroded between West Tuscarora and Conecocheague mountains. This outcrop of the Utica and Hudson River shales is an extension, through Path valley, of their great exposure in the Cumberland valley. It runs southwest along Path valley and rounding the end of Dividing mountain joins the similar beds in Amberson's valley, and both united pass into the great valley at Loudon.

Neither of these beds has yielded with certainty any fossils in the county. I obtained a few on the north slope of Conecocheague mountain, but it is uncertain whether they belong to the base of the Medina sandstone or to the top of the Hudson River shales.

*No. IV. Oneida and Medina sandstone.**

This massive and hard formation is one of the most important in the county, making all the mountains except those formed by the Pocono sandstone.

The Medina rises around three sides of the county, north, west, and south, as an almost unbroken fortification, from the Juniata river above Millerstown to the Susquehanna

*The *Oneida* (IV a) well developed further north is not distinguishable here. The *Medina* IV b, IV c.

below Marysville. Only in two places between these points is this mountain wall interrupted. At the west end the Tuscarora anticline sinks into the ground after passing for some miles parallel with the rising West Tuscarora anticline, and between them Liberty valley forms a low level passage from Perry into Juniata county. Again on the south line the Blue mountain runs out of the county into Franklin, and the range of Bower and South Bower passes parallel with it over the county line and ultimately, after passing round the syncline of Clark Knob, both unite in the synclinal point at Jordan Knob near Loudon.

The Medina sandstone is, on the whole, little eroded in Perry county, and consequently the lower beds show in only a few places. Along the whole range of the Tuscarora anticline the white upper Medina occupies the whole surface except at Run gap, near Ickesburg, where erosion has exposed the lower red bed. In Horse valley, also, where the West Tuscarora anticlinal is cleft, these lower beds, of course, show along the inner slopes of the mountain. At the crossing of Bowers' mountain, south of Blair, on the south slope, is a ravine which shows the red Medina. Also along the southern slope of the Blue mountain is another exposure, for the most part, however, in Cumberland county.

These outcrops of the red Medina thin out and disappear before reaching the Susquehanna river.

The county line in the west runs across the zigzag crest of Bower, Amberson, Rising, and Round Top mountains, and consequently the greater part of the red sandstone lies in the adjoining counties.

The Medina sandstone has afforded no fossils in Perry county, unless the few specimens mentioned above should prove to belong to it. It supplies the chief material for ballasting the Pennsylvania railroad for many miles, and is quarried for that purpose at the Juniata gap.

No. Va. Clinton group.

These rocks have been the field for much discussion regarding their relationship to corresponding beds in other

parts of the State and in other States. Included by Prof. Rogers in his No. V, they became a local group. All comparison and correlation with the previously named rocks of New York being avoided, the whole of this No. V, for reasons which do not appear to be satisfactory, has often been considered the equivalent of the Clinton group of New York. On this view the vast mass of shale of which they consist (nearly half a mile thick in Perry county) must represent the thin mass of shales and limestones with iron ore, only 80 feet thick, on which Prof. Hall conferred the name of the Clinton group. To find a great enhancement of thickness in Pennsylvania is common; but the difference here is excessive and may well make one hesitate before accepting it. Moreover, the great difference in color of the upper part of this No. V is sufficient to cause a suspicion. The lower portion sufficiently resembles the beds in New York; but the upper consists of a vast mass of red and variegated shale which has no correspondence to the New York series.

The extent of its area prevented my making as satisfactory an examination of this group as I desired, and the material obtained is yet far from being worked out, but the results already deduced from my observations and collections have led me to propose a different arrangement of the beds which have hitherto been assigned to the Clinton group. This arrangement must, however, be regarded as only provisional, and subject to alteration as further study may bring to light new data for the determination.

I propose to include in the Clinton rocks of Perry county only the lower part of those which have been hitherto referred to For. No. V. Clear physical partings exist at two or three horizons in the mass. These may be fairly assumed to indicate considerable changes of mode of deposition and of animal life. One of these is the cessation of green smooth shales, and the commencement of bright *red shale*. This is a most conspicuous plane of distinction. Another occurs at a short distance below this on the *top of the sand-rein ore bed*, over which lies a mass of green shale in part calcareous.

This ore bed, which forms a very constant horizon over its

whole outcrop in Perry county, will be adopted in this report as the top of the Clinton group.

The base of the group remains, as always, at the top of the Medina sandstone. This base I have never seen exposed, so that it is impossible for me to determine whether there is an abrupt or a gradual transition.

In Perry county, therefore, the Clinton group, as here defined and reduced, shows the following section :

Fossil iron ore and limestone,	2 feet.
Sand rock,	5 "
Fossil ore,	1 "
Sand rock,	5 "
Upper shale, {	Shale, 160 "
	Iron sandstone, 2 "
	Fossil ore, 1 "
	Shale, 200 "
Iron sandstone,	10 "
Hard fossil block ore,	3 "
Lower shale,	600 "
<hr/>	
Total thickness of Clinton group,	989 "

The thickness assigned to the different beds is not a constant quality, and the diagram does not represent any actual section. The measurements have been taken or estimated where it was possible to obtain them, and the details will be found in the account of the respective townships. Most of them were obtained either at Millerstown or in the west of the county.

The proportion of lime in the Clinton rocks increases westward, and the iron ore diminishes, and often disappears.

The only bed of iron ore which I have found in the west of the county in the Clinton group is the *sand-vein ore bed*, the bed from which all the ore now mined at Millerstown is taken.

On the other hand, there are several workable beds of lime in Jackson and Toboyne townships which do not exist further east, and which, in the absence of the thicker Lower Helderberg limestones, are sometimes resorted to by the farmers to obtain lime.

Comparison with the Clinton of New York.

Though data are somewhat imperfect and much more in-

vestigation is required before any real correlation can be established, yet the following comparison between the Clinton in New York and in Pennsylvania may not be without interest:

<i>New York.</i>	<i>Perry County, Pa.</i>
Limestone.	Fossil ore and limestone.
	Sand rock.
Iron ore.	Fossil ore.
	Sand rock.
Upper green shale.	Upper green shale and ore.
Iron ore and limestone.	Iron sandstone and fossil ore.
Lower green shale.	Lower green shale.
Thickness, 80 feet 6 inches.	Thickness, 989 feet.

Difference of opinion may prevail as to the identity of the beds of iron ore but this is of little moment. They are usually discontinuous and probably their horizons vary. But it is impossible not to notice the close correspondence in general between the two sections. No sandstone appears, it is true, in New York, and little limestone in Pennsylvania; but such discrepancies must be expected, and are due to difference of conditions during deposition. They are no argument against correspondence.

The reduction of the mass of the so-called Clinton group in Perry county brings it into close correspondence with the typical beds in New York. There is nothing in the New York Clinton like the great mass of red shale and the overlying equally thick mass of variegated shale which occurs in Pennsylvania.

The Clinton Lower Green Shale.

The solid mass of smooth, thin-bedded green shale is persistent along the outcrop, but very few opportunities are afforded for measuring its thickness or estimating its variation. Its upper portion is often exposed, but its lower beds are seldom seen, and its contact with the Medina is visible nowhere in the county to my knowledge.

These shales contain numerous thin beds of a red sandstone closely resembling the iron sandstone, of which they were the geological precursors. They are scantily fossiliferous, but time would doubtless enable the geologist to obtain a fair collection of species. Their exposures are

chiefly in roadside cuttings in the western part of the county, where the edges of the beds alone are exposed and the chance of finding fossils is much diminished

The Block Ore and Iron Sandstone.

A remarkable bed of very hard red sandstone occurs along the whole Clinton outcrop in Perry county. It is never massive, seldom measuring more than 10-20 feet, and composed of thin slabs two to three inches thick, but its power of resisting the weather is remarkable. Years of exposure seem to have no other effect than that of rounding off the corners and dissolving or removing any soft or decomposable material that it may contain. A consequence of this durability is that, though only in most places a thin bed, its slabs cover large areas on the hillsides, and seriously interfere with agriculture on what is otherwise good soil.

Five or ten feet thick in the northeast of the county, it increases to the southwest, and in Madison township measures at least 20 feet. Further south I have had no opportunity of obtaining its exact thickness; but in the Blue mountain near Landisburg it probably exceeds 20 feet.

The lower portion of the Iron sandstone is the *hard fossil block ore* of the northeast of Perry county. It is about 21 feet thick and of good quality, but is nowhere worked at present, nor exposed, so far as I am aware except near Millerstown. It does not extend over the county. I have found no trace of it in the southwest where the Iron sandstone is best displayed.

The Clinton Upper Shale.

This shale, like that below it, is only well exposed in the west of the county, where it contains more limestone than in the east, but the ore is absent. A good section through these beds is shown where the road crosses the Little Illinois valley and Brown's run; of this section, an account will be found in the report on Toboyne township. It proves the absence of the ore beds very conclusively.

The fossil ore of this shale, like that below it, lies under a thin bed of Iron sandstone. It is about one foot thick and has been opened near Millerstown, but to very small extent.

All attempts to find this bed of ore in the west of Perry county will fail unless it should, as sometimes happens, occur in lenticular masses or pockets, in which case accident alone is likely to reveal it. The greater quantity of limestone in the Clinton group of the western townships is a strong reason for doubting the presence of iron ore at this horizon.

The Sand Rock and Sand Vein Ore Bed.

This is the most important seam of ore in Perry county and the one which has contributed more than any other to its wealth. From it is taken all the ore mined near Millers-town, and, with small exceptions, all that has ever been mined there. It is of good thickness, from one foot to eighteen inches, but variable, and lies on top of the sand rock so that its extraction is easy. On both sides of the river immense quantities of ore have been taken out during the past fifteen years and the bed has been proved at various places up the Raccoon valley. At some of these it is hard and too expensive to mine; at others it is soft, but the distance from railway and canal is a great obstacle. In the present depressed state of the iron trade little is done except close to the river.

This is, however, the bed which may be sought with the greatest prospect of success in the west of the county. In numerous places there are evident indications of its presence, as in Kennedy's valley, on Buck hills and Conecocheague mountain. It is present, too, apparently in good quantity and quality. Should improved communication in the future render this ore available, some land in the west will become much more valuable than now.

The Ore Sand Rock is an unfailing guide to the place of the ore if present. As shown in the section it lies close on the top of the rock. The small, thin bed in the sandstone has no economic value even at Millerstown, and elsewhere I have not seen it.

The following analysis of the ore from this bed north of Millerstown on the river was made by Mr. A. S. McCreath, chemist to the survey:

4 F^a.

Sesquioxide of iron,	78.571
" " manganese, . . . . .	.021
Alumina,	4.927
Lime, . . . . .	.510
Magnesia, . . . . .	.213
Sulphuric acid, . . . . .	.042
Phosphoric acid,	1.502
Water and organic matter,	6.015
Siliceous matter,	8.170
Metallic iron,	55.000
Phosphorus, . . . . .	.656

In some places, as in Kennedy's valley, on the land of Mr. Egolf, this ore is very fossiliferous. The sand rock which contains one bed of ore and supports the other is itself a remarkable formation. It extends along the whole outcrop, varying, like the Iron Sandstone, somewhat in thickness, but where thickest, even in the west, not exceeding twenty feet. Some of its beds are very hard and flinty, but the upper part, immediately under the ore, is soft and pliable and very fossiliferous. It is one of the most important contouring rocks in the middle of the western townships, rising in several low rolls or arches and being the resisting layer in the Chestnut hills and other parallel ranges which have no distinct names. Fine displays of its bent strata may be seen near Beavertown at what are called the "Rainbow rocks," also near Andersonburg and near Bistline's mill, and in numerous other places.

Fossil aspect of the Clinton beds.

Very few fossils have yet been found in the Lower shale, chiefly from the difficulty of finding good exposures.

The Iron sandstone is also in few places fossiliferous but some specimens have been found which promise to be of considerable interest. There is no question however of the age of these two beds.

The Upper shale is often abundant in fossils, and their affinity is unmistakable: e. g. *Beyrichia lata*, *Calymene Clintoni*, and *C. Blumenbachi*. The same species occur abundantly in the Sand-rock, and *Beyrichia lata* and *Calymene Clintoni* continue up into the overlying Sand-vein, where they are associated with *Ormoceras vertebratum*, Hall.

We have therefore palæontological evidence, at present

scanty it is true, but quite satisfactory, of the persistence of a characteristic Clinton fauna with the Sand-vein ore bed. Here however the Clinton fauna, pure and alone, ceases.

Above the Sand-vein ore (or limestone) comes a mass of green shale and thin hard limestone bands in which fossils are scarce, but from which I have obtained two or three species. Among these are *Lingula oblonga*, Hall, found in the Clinton group of New York and *Beyrichia notata*, Hall, described from the Lower Helderberg of that State.

There are also some Lamellibranchs not yet determined.

We have here therefore a mingling of the Clinton and Lower Helderberg faunas indicating passage beds from the one system to the other, such as should be looked for at all such changes of horizon. The commingling of species is limited, so far as my observations have gone, to the belt of green shales and limestones here mentioned.

Immediately above comes the Bloomsburg Red Shale which is almost barren. Only in one or two places has it yielded any fossils that bear upon this question, and those two are the well-known Lower Helderberg forms, *Beyrichia notata*, Hall, and *Lepreiditia alta*, Conrad. No Clinton form has yet occurred.

Palæontology therefore fully bears out the proposed separation of No. V of Rogers thus:—

Onondaga group,	Bloomsburg red shale. (See Report G ⁷ .)
Passage beds,	Green shale and limestone.
Clinton group,	{ Sand-vein ore bed.
	{ Ore, sand-rock, and fossil ore.
	{ Upper green shale and fossil ore.
	{ Iron sandstone.
	{ Hard fossil block ore.
	{ Lower green shale.

These beds are thus correlated with those of the First Survey of Professor Rogers, (Vol. 1, p. 132.)

Onondaga,	Bloomsburg red shale,	Surgent Red shale.
Passage beds,	Green shale,	" Upper shale.
Clinton,	{ Ore sand-rock,	" Ore sandstone.
	{ Upper green shale and ore,	" Lower shale.
	{ Iron sandstone and ore,	" Upper slate.
	{ Lower green shale,	" Iron sandstone.
		" Lower slate.

The Niagara Group wanting.

From the identification here established it follows that nothing is left to represent the Niagara group in Perry county. If any representation of it existed it should lie at the top of the iron ore capping the Clinton group. But the green shale of the passage bed has yielded no fossils that can characterize a bed of that age. They hold, as shown above, a mingled fauna of the Clinton and Lower Helderberg ages. Consequently the Niagara group cannot be recognized in Perry county.

The rapid thinning of the Niagara group in New York would prepare us for this conclusion. Two hundred and forty feet thick at Niagara Falls, it dwindles down to about one hundred and thirty feet in Wayne county near Rochester. In southwest Ohio it scarcely exceeds 50 feet.

The Onondaga group. (Vb.)

Immediately overlying the beds just described at the top of the Clinton group, is a mass of shale with a few interbedded sandstones 1500 or 1600 feet thick. These constituting the upper part of Rogers' No. V, should occupy the place of the Onondaga of the New York series.

The Onondaga, Salina, Salt, or Gypsiferous group of New York consists, like the above-mentioned strata, of a mass of shales of various colors, and as the names imply yielding salt and gypsum. The total thickness given by Vanuxem in the report of the Third district is about 700 feet, divided as shown below. The section in Perry county is given in another column for comparison.

<i>New York.</i>	<i>Perry co., Penna.</i>
Magnesian rock=limestone with stylolites.	
Gypseous bed, (upper,) . . }	Gray calcareous shale, 200 feet.
Porous (vermicular) lime-rock, }	
Gypseous bed, (lower,) . . }	
Variegated shale, red and green, .	Variegated shale, red and green, 700 ft.
Bloomsburg red shale,	Red shale, 700 ft.

The thickness of the group in New York varies from 300

to 1000 feet. Its thickness in Perry county is about 1500 feet.

Onondago red and variegated shales.

A very close agreement may be observed between these beds in the two States. In both they consist at base of a thick mass of red shale overlain by another of varying color. Indeed the descriptions given of these lower beds in New York might be copied literally and applied to the Pennsylvanian rocks.

Vanuxem says (Rep. on 3d District, p. 96) of the red shale: "The great mass is of a blood-red color, fine-grained, earthy in fracture, breaking or crumbling into irregular fragments." And of the variegated shale he says (p. 97): "It consists of shales and calcareous slate of a light green and drab color, intermixing and alternating with the red shale at its lower part." Thus we have at the top of the series, green, then red under it, green, red, bluish-green and yellow, this latter by exposure to the air; then green and red layers with a little white and greenish sandstone, being several repetitions of the first two, and finally red shale as the lowest visible mass.

No better description can be given of these two groups as they occur in Perry county.

The thickness of the separate beds is not mentioned in the Report of the New York Survey, but in Perry county they form two masses of about 700 feet each, giving to the whole group, as usual, a thickness considerably greater than that which it has in New York.

Again (p. 97): "In several localities the red shale shows numerous green spots, varying from an inch or two to several inches in diameter." "The red shale presents a thickness of from one to nearly five hundred feet, yet nowhere has a fossil been discovered in it, or a pebble, or anything extraneous excepting a few thin layers of sandstone."

Similar green spots occur in the Red shale in Perry county, as near Waggoner's mills and other places. The great scarcity of fossils is also remarkable, though they are not totally absent in Pennsylvania, as will be seen below.

These Red and Variegated marls of the Onondaga group occupy a very large area of Perry county, especially in the west, where they are exposed by the erosion of the overlying beds. The Red shale area is fringed along its whole, or nearly its whole, outcrop by the Variegated shales, which run out into long tongues as shown on the geological map. The whole of the long strip running from Loysville eastward, with the exception of a small part near Loysville, consists of the Onondaga variegated shales. Both these and the underlying Red shales form a warm fertile soil when disintegrated, and for this reason the west of Perry county is a better farming district than the east.

Onondaga Bloomfield sandstone.

Near the top of the second division of the Onondaga variegated shales occurs a thin bed of soft friable sandstone, breaking up into rectangular, brick-shaped fragments. Like the shales it is of varying colors, dull reddish and greenish, and is about ten feet thick. Being harder than the beds adjoining it, its presence is usually indicated by a well-marked low ridge running along its outcrop. This may be well traced in Centre township. It passes under New Bloomfield, and a good section of it may be found on the road to Newport, half a mile east of the town. Other sections are visible at various places along the valley road.

This sandstone is one of the beds containing *Leperditia alta* in great abundance, both at New Bloomfield and at Landisburg. It also possesses great interest and importance from having yielded the fossils of which an account will be found in another place.

This is no doubt the bed which Prof. Rogers describes in Geol. Penn., 1858, (p. 329.) "In the upper part of this mass, the Scalent gray marl, near the bottom of the *Scalent limestone*, there is a bed of argillaceous sandstone in layers of various colors, dull red, gray, white, and greenish. This rock which breaks up into *small rectangular fragments* has a total thickness of only 8 or 10 feet, and yet owing to its superior hardness to the underlying marls it generally forms a decided feature to the surface, occupying a low ridge by

which it and the strata adjoining it may easily be recognized."

It occurs however near the top of the *Variegated* shale, not of the *Gray* shale, in which horizon no such bed exists in Perry county.

A great error in stating the thickness of the *Variegated* marls also occurs on the same page. They are said to be "probably not more than 100 feet thick," near Tuscarora mountain. They are 700, as stated above.

Onondaga gray shales.

In regard to the uppermost part of the New York Onondaga deposit the comparison made above is also to a great extent true. The description given of it is largely applicable to the upper part of these Pennsylvanian shales, the Scalent gray marls of Rogers. Vanuxem says, (p. 99:) "The great mass of the deposit consists of rather soft yellowish or drab and brownish colored shale and slate both argillaceous and calcareous." So in Perry county, though seldom well exposed, the mass is of this kind. It contains "argillaceous and calcareous slaty and more compact masses which are hard."

But there is no evidence in Perry county of the presence of those concretions of gypsum which characterize the upper part of the Onondaga in New York, and which together with its brine springs render it the most valuable rock in the State. The gray shales contain no valuable mineral except the lime which enters largely into their composition and which gives the soil derived from their disintegration a value almost equal to that of the adjoining "limestone land." Their area is not large, forming only a narrow fringe between the variegated shale and the base of the Lower Helderberg limestone. Owing to their softness, also, they are seldom exposed.

The great barrenness of these shales in the matter of fossils prevents the production of satisfactory evidence of age. Only two or three species have rewarded a considerable amount of search. Of these the only one that occurs in any quantity is *Leperditia alta*, which has been

found in the Red shale in a few places abundantly, near Buffalo Mills, for example, in the Buffalo valley, Saville township. It is also found in the second division—the Variegated shale—in Centre township, and becomes exceedingly abundant in its upper portion, whole slabs being completely covered with its casts. The Gray beds afford few opportunities for examination; but it (*L. alta*) runs up through the massive limestone which in this county makes the lowest division of the Lower Helderberg rocks. Above that level I have not found it. In regard to this species in New York State, Vanuxem says, (l. c., p. 99:)

“At one place only I succeeded in finding fossils in the second deposit, (the Variegated shales,) consisting of Cytherinæ (Leperditia) about half the size of those in the groups above and below the salt group.” In this respect, therefore, the correspondence is exact.

No fossils having been found in the red shale in New York the presence of *Leperditia alta* in those of Perry county, though not without importance, does not bear on the correlation. It has been mentioned that in the green shale passage beds at the base of the red shale the Lower Helderberg species *Beyrichia notata* has been found. This may seem at first an objection against the classification here adopted. But when we consider that the range of *Leperditia alta* has been extended downward to the red shale, there is no improbability in supposing that *Beyrichia notata* which ranges equally high may descend a little lower. It would not be wise to decide against an arrangement that so well harmonizes with many facts on account of so small an objection as this. Neither palæontology nor stratigraphy must decide such questions alone—they must work hand in hand. Moreover, as the red shale in New York is reported barren it is impossible to compare the two beds in this respect.

In the geology of the Fourth district Prof. Hall describes eight species from the Onondaga shale, but does not say from which division they were obtained. The locality of seven of them, Newark, being near the south line of Wayne county, it may be inferred that they do not belong to the

red shale. The only other species named by Prof. Hall is a *eurypterus* from Williamsville, Erie county, which cannot be from the red shale, as that bed is said not to be found west of the Genessee. Its indications are of Lower Helderberg affinities, in this respect agreeing with those of *Leperditia alta* and *Beyrichia notata* above-mentioned.

Onondaga Bridgeport sandstone.

In the mass of red shales comprising the lower part of the Onondaga lies a bed of hard flinty sandstone deserving some notice. Its occurrence in so thick a mass of shale is very surprising as is also its small extent. It is merely a local patch of quartz sand thinning out in all directions from a center near Bridgeport, whence the name.

It is difficult to account for the presence of so large a mass of this material so deposited. From what source can it have been derived? How was so limited a mass of sand transferred or deposited in a thick mass of red shale without connection with any other similar deposit? A similar bed, perhaps the same, may be seen in the red shale near Bistline's mill, in Madison township. It is only two feet thick. (See report on Madison township.) No sign of any such bed can be seen at other exposures of the red shale at intervening points, as at Waggoner's mill, where an almost complete section can be got.

The two exposures of the Bridgeport sandstone, at which it is best shown, are near Bridgeport, on the bank of Sherman's creek and near Mr. Egolf's mill, in Kennedy's valley. For details of these see report on Tyrone township.

The occurrence of these two beds at so distant places with no signs of similar beds at intervening stations, suggests the possibility of a shallowing of this part of the ancient ocean over a considerable area, producing sand-banks on which the heavier material was accumulated, while the finer parts were swept away. This, if true, must be accompanied by a less thickness of the red shale under and near the sandstone deposits. Of this, however, I have found no evidence. The only place where an opportunity of making such a measurement has offered itself being in Madison township, near

Bistline's mill, where the sandstone, about 5 feet thick, lies on 500 feet of Red shale, and under about 200 feet more, giving as a total amount 700 feet, the same as elsewhere.

In this connection may be pointed out the approximate contemporaneity of the formation of these beds of sandstone, however deposited, with the shallow water or dry area in Rye township at the close of the Onondaga area. See report on Rye township.

No. VI. Lower Helderberg group.

The rocks of the Lower Helderberg group possess in this county a well defined summit, but an ill defined base. Upwardly they stop at the base of the Oriskany sandstone, but downwardly they graduate into the shales and marls of the just described Onondaga group. It is consequently impossible to draw a clear plane of division between these groups, and certain passage beds must remain debatable ground. In this case also the classification adopted is merely provisional pending the collection and study of fossils from these beds in other parts of the State, many of the beds being almost barren in this county.

The Lewistown (Bossardville) limestone.

The Lower Helderberg rocks, largely of limestone, are the only beds much quarried for lime. Commencing below we find, first, a mass of hard, dark, often bituminous and sparry limestone, in beds several of which are from two to four feet thick. Above and below these they become thinner with increasingly numerous partings of shale. This massive limestone is the lowest to which the name of the Lower Helderberg is here applied. Minute examination of a weathered surface shows that it is composed of alternate very thin layers, which show darker and lighter tints but no tendency to separate. All these beds are burned at different places and yield ordinary quicklime. I have seen no indication of hydraulic properties in any of them. The burnt stone slakes readily in the air. The thickness of this part of the group, so far as can be judged from numerous but imperfect exposures, does not exceed 100 feet.

The Clark's Mill beds.

Overlying this is another mass of thin-bedded limestones and calcareous shales in some places, perhaps generally, from 100 to 150 feet thick, yielding a lime of the same quality as the last, but from its less massive and more shaly nature seldom opened where the other is accessible. I have found but one good exposure of these beds in the county. This has afforded the typical section an account of which may be found in the report on Centre township. (See Clark's Mill section.) A striking feature of these beds, wherever exposed, is the abundance of their fossils, which consequently afford the means of a full collation with those of other places, especially of New York.

The yellow flint shale.

Towards the top these beds become very corniferous, the limestone giving place to black chert in lenticular sheets often with a limestone crust. Higher still follows a thick mass of shale with bands of yellow flint which I have found nowhere well exposed in the county. At the same time its outcrop is very well marked along the whole space between the limestone and the Oriskany sandstone, and it forms in connection with that next to be described the soil known all over the county as "Flint-gravel." The flint lies apparently in thin sheets which break up readily under the action of frost and become bleached by the air and light, so that the fields present a perfectly white surface and are sometimes so thickly covered with stones that it appears as if no crop could grow on it. Yet it is not unproductive, but ranks high among the soils of the county.

The white flint shale.

Above this yellow flint shale lie two beds of white flint more massive but only exposed in a few places, as, for instance, at Half Falls mountain, near the mouth of Cocalamus creek, and in the northwest of Juniata township. It crops out in two beds each about twelve inches thick and separated by about two feet of shale. This flint cumbers the fields along its line of outcrop with masses often measuring

a cubic foot, and must consequently be picked off by hand before the land can be cultivated. In this it differs from the yellow flint, which breaks down into small pieces which do not interfere with the plow. The white flint is also very fossiliferous, the yellow flint being comparatively barren, and its fauna may be examined on the huge stone-piles which often skirt the fields along its outcrop. Owing, however, to the square-fracturing and brittle texture of the stone it is almost impossible to secure specimens without at the same time carrying away a great weight of the stone.

At a few feet above these white flint shales the Oriskany sandstone appears in full force, the transition being apparently abrupt though nowhere exposed.

Section of Lower Helderberg rocks

Oriskany sandstone.

Lower Helderberg.	{	White Flint shales,	10 feet,	}	348
		Yellow Flint shale,	80 "		
		Black Cherty limestone,	8 "		
		{ Tentaculite bed,			
		{ Polyzoön bed,			
		{ Beyrichia granulata bed,			
		{ Leptaena bed,			
		Clark's mill { Stromatopora bed,	150 "		
		Lime shales, { Sphaerocystites bed,			
		{ Rhynchonella bed,			
		{ Murchisonia bed,			
		{ Beyrichia notata bed,			
		Lewistown Limestone, massive,	100 "		

Full details may be obtained from the township reports. The lime shale, though very persistent, is apparently absent at the exposure under Half Falls mountain.

The following section will enable the reader to compare the Lower Helderberg rocks of Perry county with the exposures in New York as given in the survey of the State :

<i>New York.</i>	<i>Perry co., Pa.</i>
Upper Pentamerus limestone.	
Encrinital limestone,	Flint shales.
Delthyris (Spirifera) shaly limestone,	} Lime shales.
Lower Pentamerus limestone,	
Water lime, (Tentaculite limestone,)	Massive limestone.

It is difficult to correlate these two sections with any de-

gree of minuteness, but there is a general resemblance which is not to be overlooked. In a palæontological sense also there is both agreement and discrepancy.

In the Lewistown massive limestone very few fossils can be found in Perry county, and the only one that can be looked for with any reasonable expectation of success at most exposures is the little *Leperditia alta*, Conrad. As this species has thus far not been seen in any of the higher divisions, but ranges downward to a great distance, it cannot be called a special characteristic of this limestone in the county.

In New York the Water-Lime is characterized by this *Leperditia*, and by several other species, among which is *Tentaculites ornatus*, Hall, (= *T. gyracanthus*, Eaton; *T. irregularis*, Hall,) a species which in Perry county occurs at a higher level (see section) with *Spirifera Vanuxemi*, Hall, (= *Orthis plicata* Vanuxem.)

The lime shales of Perry county correspond well in a general way with the Lower Pentamerus limestone and the Delthyris shaly limestone of New York, though, on descending into minute details, the resemblance is less close. This is, however, no more than should be expected considering the distance that separates the two places. We have in both the same profusion of fossils, the calcareous composition of the rocks, and, to a great extent, the same species prevailing on slightly different horizons. The following partial catalogue will show the general resemblance between the faunas of the two States.

Partial list of fossils common to the lime shales of Perry county, Pennsylvania, and the Lower Pentamerus limestone and Shaly limestone of New York:

<i>Discina discus</i> , Hall.	<i>Meristella lævis</i> , Vanuxem.
<i>Strophomena rugosa</i> , Dalman.	“ <i>bella</i> , Hall.
<i>Rensselaeria mutabilis</i> , Hall.	<i>Megambonia aviculoidea</i> , Hall.
<i>Rhynchonella nucleolata</i> , Hall.	<i>Murchisonia minuta</i> , Hall.
“ <i>formosa</i> , Hall.	

This list might be much extended by further study and collection. The total absence of the genera *Platyceras* and

Pentamerus is worthy of notice, no specimens having yet been obtained. It should, however, be borne in mind that only one exposure (Clark's mill) has been closely examined, this being the only good one found in the county.

The Flint shales overlying the Lime shales afford few fossils except in one horizon—the *White flint*. These beds are often crowded with casts among which *Sp. macropleura*, Conrad, and *Strophomena rugosa*, Dalman, are especially abundant. At the base of these shales the bed immediately overlying the black cherty limestones, and perhaps the latter also to some extent, abound with silicified *crinoidal joints* and may perhaps be an equivalent of the encrinital limestone of New York. There is however nothing in the New York section resembling the immense flint deposit of Perry county. These however are apparently of limited extent, as I found no sign of their presence in Huntingdon county, where, at the Mapleton sand-works, a good section is shown in the tunnel by which the sand is brought out of the quarry. The whole interval there shows only soft shale of different colors, chiefly red and yellow.

It appears then that with a general resemblance amply sufficient to establish their correspondence, there are numerous smaller discrepancies such as would be likely to appear at a distance of between 200 and 300 miles from the outcrop in New York.

No. VII. Oriskany Sandstone.

This remarkable but variable bed is found in Perry county in almost every place where its outcrop might be expected. It forms one of the most conspicuous features of the map, zigzagging back and forth as the various minor folds in the strata bring it to the surface. It nowhere exceeds 20 or 25 feet in thickness; it varies from white through yellow to red, and in hardness from pure sand to a flinty rock. In some places it is a mass of small white quartz pebbles like white beans; in others it is a clean sandstone.

In Pfoutz's valley it is very thin or in some places entirely absent.

Along Sherman's creek it attains its greatest development.

It is often fossiliferous, but the fossils, or rather the casts, are indistinct and fragile.

In the northwest part of the county it is very ferruginous sometimes simulating a poor iron ore, but in no part of the county does it yield anything of commercial importance except an inferior stone for rough walls. Neither glass-sand nor iron-ore has been found in it.

Its pulpit rocks often afford picturesque scenery, especially near Bloomfield.

In those parts of the county where the Lower Helderberg limestones are specially folded the Oriskany sandstone is usually included in the fold, occasionally inclosing the Marcellus ore and shales; but as often these have been nipped out and the sandstone alone remains.

The extension of so thin a sandstone over so wide an area makes the question of the mode of its formation both difficult and interesting. No local cause can explain its origin. The most probable opinion seems to be that it indicates an age when from some cause, perhaps subsidence elsewhere, the flat bottom of the palæozoic ocean was laid dry, and the waves sorted and sifted the accumulated material, washing away the finer and lighter portion and accumulating the coarser and heavier on banks and shoals and spits, distributed according to the direction of the winds and currents, but with tolerable uniformity. The adoption of this opinion, it must be remembered, implies the admission of great destruction of preëxisting deposits in order to form so vast sand beds, for the shales underlying the Oriskany, though flinty in Perry county, do not usually afford much siliceous material. This view is beset with fewer difficulties than any one which involves the introduction of the sand from outside the Oriskany area and its even distribution.

The absence also, now certain, of the next overlying group, the Upper Helderberg or Corniferous, strongly confirms the belief that Perry county and the adjoining part of Middle Pennsylvania was dry land or shallow water during this interval. To some extent then the Oriskany sandstone of Perry county may be coeval with the Corniferous

limestone of surrounding districts. Apparently, too, the black Marcellus shale is thinner than in many other parts of Pennsylvania—a fact quite in harmony with the above suggestion.

We may possibly, therefore, have in the interval and gap between the Oriskany Sandstone and the Marcellus a second dry land area in Perry county considerably later than that described in the report on Rye township.

No. VIII a. Upper Helderberg (Corniferous) group.

The Upper Helderberg or Corniferous Group being, as above mentioned, absent over the whole county, the lowest of the Hamilton rocks rest directly in most places upon the Oriskany Sandstone. For the reasons which have led to the adoption of this opinion the reader is referred to the report on Madison township.

No. VIII b. Marcellus limestone and black shale.

Overlying the Oriskany sandstone is a series of shales and limestones which palæontological evidence places in the Marcellus division of the Hamilton group. They are all constant, except in the southeast, but vary in thickness at different outcrops in the county. The lower portion of this series has been regarded as the representative of the Corniferous limestone of New York, but my observations decide against this identification.

The Marcellus beds in Perry county may be thus divided :

5. Marcellus Black Shale,	100 feet	} 204
4. Marcellus upper iron ore,	2 "	
3. Marcellus Limestone,	50 "	
2. Marcellus Lime Shales,	50 "	
1. Marcellus lower iron ore,	2 "	
Oriskany Sandstone.		

1. The lower iron ore is of little value; it has been dug for paint in one or two places but is worthless as an ore. (See chapter on iron ores.)

2. Marcellus Lime Shales. This bed is of very uniform thickness wherever it appears throughout the county. It consists of thin beds of a very argillaceous gray limestone and of shale of the same color. In most parts of the county

it has yielded no fossils, or they are so indistinct and difficult of extraction as to be nearly worthless, but at its north-western exposures it is fossiliferous and here was obtained the evidence of its position. (See report on Madison township.)

3. The Marcellus Limestone is only a continuation upward of the shales with an increase of lime to such an extent that the beds are very hard and solid, especially in Madison township, and can be burnt into good lime. They are for the greater part of their thickness interbedded with thin seams of dark shale, which gradually increase in number and thickness until they merge in the overlying beds of the black Marcellus.

4. The Marcellus Upper Iron Ore will be found described in the chapter on the iron ores.

5. The Marcellus Black Shale. This formation presents few features of interest in the county. It is almost unfossiliferous at all the exposures where I have examined it. Its thickness is very uniform. At its base it is very ferruginous and even pyritous, but these features disappear upward, the blackness diminishes and it passes gradually into the base of the Hamilton Lower Shale. The exception to be noted in regard to the fossils is that at almost every outcrop in the county the lower beds yield in great abundance the minute vegetable remains which have been described from beds of similar age in Canada, by Dr. Dawson, under the name of *Sporangites*. (See "On Rhizocarps in the Palæozoic Period," Dr. J. W. Dawson.) The same or similar fossils have been reported by Prof. E. Orton, of Columbus, Ohio, from the Marcellus beds of that State. Whatever these fossils may be their wide extension on this horizon is thus rendered certain.

The soil formed by the disintegration of the Marcellus black shale is among the poorest in the county but it yields the very best material for roads. Accordingly the roads upon its outcrops or near them are often smooth, dry, and hard, as those at Little Germany and Centre Mills. Unfortunately these outcrops are few and far between.

No. VIII c. Hamilton group.

The Hamilton group in Perry county consists of a great mass of strata comprehending almost all kinds of sedimentary material. The following section represents its general components and dimensions including the Marcellus :

Hamilton Upper Shale,	200'— 300'	} Average, 900'
Hamilton (Montebello) sandstone,	500'— 800'	
Hamilton Lower Shale,	400'— 500'	
5. Marcellus Black Shale,	80'— 120'	
4. Marcellus Iron Ore,	2'— 14'	
3. Marcellus Limestone,	10'— 40'	
2. Marcellus Lime Shale,	20'— 40'	
1. Marcellus Lower Ore,	2'— 3'	
Oriskany Sandstone.		

The Hamilton lower shale.

The lower shales of the Hamilton group consist of about 500 feet of olive sandy shale often with interbedded thin sandstones of the same color. They are generally much stained with iron toward the lower portion, sometimes containing thin layers of poor hematite. Downward they graduate imperceptibly into the upper beds of the Marcellus, growing darker and darker. Upwards they pass as imperceptibly into the basal beds of the Hamilton sandstone, becoming more and more sandy until solid sandstone ensues. Their thickness is very constant, apparently greater in the northwest ; and they extend over the whole county except the small district on the southeast described in the report on Rye township.

These shales are soft and their disintegration has in part produced the broad valleys that usually run along between the ridge of Hamilton sandstone and those of the Oriskany, if the latter is hard enough to form one ; if not, the valley eroded in the Lower Hamilton shales blends with that of the Marcellus. Oriskany and the upper part of the Lower Helderberg.

The soil produced by the disintegration of these shales is lean and poor, and easily distinguishable by its whitish hue. In some places it extends over considerable areas, as at the west end of Dick's hill, about Little Germany, and

south of Sandy hill. But they are usually of less width and much covered with wreckage from the Hamilton sandstone, or Oriskany, or both.

The Hamilton Montebello sandstone.

The Hamilton sandstone is one of the most remarkable deposits of Perry county. Lying in the midst of a vast mass of material, consisting almost entirely of shale, it has the appearance of being out of place to the geologist accustomed to look on the Hamilton as essentially a soft group. The valleys excavated in the Hamilton shales in most parts of the palæozoic belt here give place to high, rough, wooded ridges, especially in the southern part of the county.

Turkey ridge, and Wild Cat ridge in the northeast, Racoon ridge, Buffalo hills, Mahanoy ridge, Dick's hill and its geological continuation, Rock hill, in the central portion of the county, with Pisgah hill and Little mountain in the south, are all formed by the outcrop of this sandstone. Some of these are high, rough and untillable, others are comparatively smooth and accessible. The difference is due to two causes—the hardness and the dip of the sandstone. In Mahanoy ridge the strata are nearly vertical, and the ridge is steep and rugged. In Buffalo hills and Dick's hill the beds dip at about 45°; while in the neighborhood of Sandy hill the dip is very gentle, and the range is cultivated to its top on the south side. Then again the proportion of sand rapidly diminishes toward the north and west, especially in the middle of the bed. This also tends to diminish the steepness and roughness of the ridges.

At its southeastern exposure near Marysville, this sandstone attains its greatest thickness and hardness, a thickness amounting to about 800'. From this point it gradually thins away, the upper and lower beds persisting farthest, and the intermediate shale becoming constantly thicker, until it at length becomes two distinct thin sandstones, with an intervening thick bed of softer material. This change may be detected in Perry county. At Montebello narrows the Little Juniata has cut its way through the lower hard bed and has then flowed for nearly half a mile parallel to

the ridge and between the two sandstones, at length crossing the upper, thus producing a zigzag channel. Evident traces of the change may be seen in Pfoutz's Valley and near Sandy hill. But outside the limits of the county it becomes manifest. At and near Huntingdon the two sand layers may be distinctly traced only a few yards thick, the upper being the heavier, and the great mass of the bed has become shaly. This is only 60 miles in a straight line from its point of greatest development on the Susquehanna. The Hamilton sandstone is, therefore, a mass of coarse material, intercalated near the middle of the group, and spreading fanwise as from a center near Marysville, dying away and at length disappearing as it recedes from that point. Further details and deductions from the observed facts on this stratum will be found in the report on Rye township.

The Hamilton upper shale.

These shales extend, so far as my observation has reached, over nearly all that part of the county occupied by the Hamilton sandstone. It overlies that formation, being separated from it only by the Montebello fossil ore. The transition is much more abrupt than that between the lower shale and the sandstone. The shale is also much smoother, contains very little sand, almost none toward its upper part, is peculiarly soapy to the touch, olive green in color, with ocherous weathered surfaces for the most part, and in its upper portion remarkable for the abundant fossil fauna which it yields, altogether of marine types. These fossils are also ocherous or black from the presence of iron.

The Hamilton upper shale lies along the slopes of the Hamilton sandstone ridge, and is usually much concealed by the fallen wreckage. It is exposed, however, at several places on the south side of Mahanoy ridge, near Bloomfield; near Drumgold's tannery on Sherman's creek, in Carroll township; near the crossing of Inoculate run on the Newport-Bloomfield road; between Buffalo hills and Little Buffalo creek on the land of Mr. Toomey, &c., &c.

The Hamilton upper shale may be divided in Perry county into the following beds:

Hamilton upper shale.	{	Fenestella shale,	15 feet.
		Tropidoleptus shale,	15 "
		Barren shale,	200 "
		Paracyclas shale,	2 "
		Montebello fossil ore,	2 "
Hamilton Montebello upper sandstone.			

The two uppermost of these beds have proved the richest fossiliferous strata in the county, having yielded more than a hundred species of fossils described and undescribed. No clear line of demarkation can be drawn between them, the upper being marked in most places by a profusion of *Fenestella*, especially near the top; and the lower by an abundance of the fossil from which it derives its name. This species is not, however, confined to one horizon. It ranges down into the Hamilton sandstone, in the upper layers of which it is exceedingly abundant. In the intermediate Barren shales few or no fossils can be found; and in the Paracyclas shales below them the species differ largely from those in the uppermost bed, *Paracyclas lirata* being the more characteristic form. The iron ore will be described elsewhere.

No. VIII d. Genessee group.

This group was not recognized until a late date in the work, and its barrenness renders its identification difficult. Lying, however, as 200 feet of black, almost unfossiliferous shale, between the fossiliferous Hamilton upper shale and Portage shale, its place became evident as soon as those were identified, and by this means it was traced over the county. Its lower beds yield the Genessee species *Styliola fissurella* near New Bloomfield. Its total thickness is not more than 200 feet.

No. VIII e. Portage group.

Like the Genessee, these rocks were among the last identified, but are very constant, and their fossils sufficiently abundant to occur at most localities. The commonest and one of the most characteristic is the *Cardiola* (*Avicula*) *speciosa*, described by Prof. Hall, from the Genessee of New York. Other species also occur, some of them ap-

parently new. Localities will be found mentioned in the reports on the townships. The thickness does not exceed about 200 feet.

No. VIII f. Chemung group.

The rocks of this age occupy a large area in the county along three separate outcrops.

The most northerly of these is a curve coming out and running round the west end of the Buffalo syncline. Its extreme length is about 44 miles.

The second or southern outcrop of the Chemung shales is a similar curve running round the west end of the Cove syncline. The total length of this curve is about 26 miles.

Between these two outcrops is another of less extent, a long narrow monoclinical strip skirting the south slope of Mahanoy ridge. It is originally the northern part of a third syncline which lay between Mahanoy ridge and Dick's hill, the southern portion of which has been cut off by the Perry county fault. Eastwardly also this Chemung outcrop is limited by the duplication of the Hamilton rocks at the end of Mahanoy ridge, which forms the continuation on another line of the Perry county fault and the third summit of Half Falls mountain. The details of this continuation and repetition of the fault will be found in the report on Watts township.

The Chemung group in this county consists entirely of olive shales and fine-grained, thin-bedded sandstones. They may be distinguished after a little practice from the Genesee and Portage shales below them by their lighter color. Upwardly they change gradually in most places into the Catskill red shales by becoming more and more stained with iron. This change is specially noticeable in the northwest where the Upper Chemung shows a much closer approach both in color and fossils to the corresponding beds in the northern part of the State. See report on Saville township.

The group is well characterized by its fossils, though these are rarely found in good preservation, the contortion and pressure to which the rocks have been subjected having

broken, crushed, and distorted them often past recognition.

The thickness of the Chemung rocks in this county diminishes rapidly from north to south.

Above Newport they are, as nearly as I have been able to determine, about 3300 feet thick.

In the middle monoclinal outcrop no measurements could be obtained.

In the southern trough near Rockville the combined Genesee-Portage-Chemung rocks measure only about 1100 feet.

This indicates a diminution in a direct distance of about fifteen miles of more than 2200 feet.

It has proved impossible to determine, with the time and means at my command, whether or not this diminution extends westward from the river. Extreme caution is required in obtaining these dimensions in Perry county. Concealed folds, extension of anticlines, and the presence of faults destroy the value of many exposures for this purpose.

An instance in point occurs near Newport, where, by overlooking the eastward extension of the fold at Inoculate run, a thickness has been assigned to the Genesee shales *six times too great*, 1120 feet instead of 200 feet.

In like manner at the end of the northern syncline a set of small anticlinal folds run in from the west, flattening and reversing the dip and rendering the measurement of thickness impossible.

The great expanse of the Chemung rocks is unfortunate for the farmers of the county. Yielding by decomposition a poor, thin soil, only good farming can render it productive. The poorest lands in the county, with some slight exceptions, are those upon the Chemung shales. This is especially conspicuous in the northern syncline on Middle ridge and Hominy ridge, both of which are chiefly composed of Chemung rocks. These have been cleared for the most part, the former almost entirely, but in many places have since been abandoned and are going back into woodland, being partially covered with a young growth of scrub pine (*P. inops*), a worthless kind of timber.

The surface of the Chemung shales usually consists of

low, rounded hills showing less definite direction than the harder groups, and cut across in both directions by streams. Occasionally the beds are hard enough to form steep slopes, or even bluffs, as near Montebello Furnace and Newport, but these are unusual. The smooth, evenly rounded hills and slopes of Chemung shale present to the eye a pleasing contrast with the rugged outlines of the Hamilton sandstone hills adjoining them. Their irregular drainage and erosion are due to the want of hard beds to divert the water-courses. Consequently weathering proceeds with equal ease in all directions and chance alone determines the contour of the surface. This chance contains three chief factors—original variation of level, local softness in the rock, and accidental diversion of the water-courses. None of these can be predicted, and consequently the drainage of these Chemung districts follows no general law.

No. IX. Catskill formation.

This easily distinguished group of rocks, so conspicuous by its massive red beds, is an important factor in Perry county geology. It occupies the middle areas of both synclines, Buffalo and Cove.

The immense thickness of the formation, about 6000', combined with the moderate dip at which its beds lie, gives a great breadth to its outcrop. This is increased by the occurrence of numerous smaller local folds, especially in Wheatfield, Penn, and Watts townships. Fine sections of these may be seen along the bank of the Juniata river north of Duncan's Island, where the Chemung rocks are included in the wrinkles.

The upper limit of the Chemung is not always very clearly defined. The Chemung rocks gradually assume a red color, and the peculiar, thin, fine-grained sandstones which characterize them disappear. But in most places there is no great difficulty in limiting the bottom of the Catskill. Occasional red beds occur near the top of the Chemung, but the division, for the purposes of this report, has been drawn where the great mass of red sandstone and shale begins to appear. About this horizon also the olive-gray

shales of the Chemung are succeeded by yellow shales which also serve as a distinguishing mark.

At a short distance above this level the Catskill type is distinctly marked, palæontologically, by the occurrence of its characteristic first remains. In the southern basin these are found on four distinct horizons, the lowest of which is within 100 feet of what has been assumed as the summit of the Chemung. They consist of scales of *Bothriolepis* and *Holoptychius*, the former being specially abundant. In the northern syncline few traces of these fossils have been found, but these traces are as nearly as possible upon the same level. The inference is therefore warranted that the top of the Chemung lies, both on stratigraphic and palæontologic evidence, at or near the dividing plane between the olive shale and the red sandstone.

The beds overlying the Chemung group in Perry county are unusually interesting, having afforded a large number of fossil remains.

The fish beds.

The first of the beds in question is the lowest fish bed, which being double may be considered two beds. It is a complete mass of scales, for the most part broken, and from the crumbling nature of the stone very difficult to extract.

Above this, with an interval of about 200 feet, is a thin bed (4 inches) of green shale filled with casts of *Spirifera mesostrialis*, a Chemung species.

The King's Mill sandstone.

More than two hundred feet higher still comes the most remarkable bed in the whole series, which I have called the King's Mill sandstone, from its specially clear exposure near King's Mill, two miles northwest of Duncannon. It is here exposed in the fields of Mr. G. Brunner (and by the roadside at Linton's hill a mile to the west) as a bed of white sandstone, some lenticular layers of which are merely masses of stone honeycombed by the cavities left by the solution of the shells of *Schizodus rhombeus*, Hall, and others, mostly Lamellibranchiates. These fossils occur only in places. If

the sandstone, which usually forms a ridge on the surface, be followed west from Linton's hill it will be found almost barren ; and the same is true of its exposures east from its outcrop at King's Mill. This sandstone exhibits a mingling of some Chemung forms with others not described, the most conspicuous of the former (though not yet found at King's Mill) being *Sp. disjuncta*, Sby.

A few miles southwest from the exposure just noted, this sandstone is again seen, but not in place. Its characteristic ridge and fossils are conspicuous near Shermansdale mills, where, however, numerous species occur not found at King's mill. The specimens also are in better condition, and many belong to large species of Lamellibranchs. They are also here exceedingly ferruginous, a mass of red, purple, or black oxide of iron often occupying the places of the dissolved shells. Want of time prevented my tracing this bed along the southern outcrops of the syncline, but there can be little doubt of its continuance.

In the northern part of the county its outcrop is easily found and traced. It constitutes in great part the axis of western Middle ridge, and curves round the end of the Buffalo syncline, returning along the southern side of Hominy ridge. It is conspicuous in Saville and Juniata townships as mentioned in those reports. Fossils, however, are not abundant, and I have seen in the northern syncline no such evidence of abounding life as near King's mill and Shermansdale. Fossils exist, however, and can be found in numbers amply sufficient for identification of the stratum.

East of the Juniata the King's mill sandstone ranges along Wild Cat valley from one river to another in two nearly parallel outcrops. Here, too, its fossils, though scarce, are not difficult to find.

In Watts township also the line of outcrop continues, and the sandstone here forms an almost continuous low stony ridge along which its fossils, especially *Sch. rhombeus*, may be collected.

From the above evidence the inference is just that the King's mill sandstone extends over the whole of the Lower Catskill area in the county, as a continuous bed, about

500 feet above the assumed upper limit of the Chemung. Its fossil contents indicate a transition state, during which Chemung species yet lived, though the ground had been already twice occupied by the great ganoid of the Catskill.

It is not a question of much moment into which formation this fossiliferous sandstone falls. Some may prefer to regard it as the top of the Chemung, others as belonging to the Catskill. In regard to the former view it must be stated that other fossiliferous beds occur above it to a height of more than 500 feet, (see report on Penn township,) and that in these beds is found a very small form of *Spirifer*,* and the only Chemung species yet seen above the sandstone. In regard to the latter view it must be said that these fossils have not previously been recognized anywhere in the great mass of the red sandstone and shale comprising the Catskill group. Yet, through its lower part, I have found the same or kindred species; and Prof. White has also reported them from beds in other parts of the State similarly situated, but ranging to nearly 2000 feet above this assumed base of the Catskill.†

Moreover, as these fossils often occur in the solid sandstone and red shale with the remains of ganoid fish, we cannot assert that they are an indication of the return of Chemung conditions bringing with them Chemung species. The fossils, to whichever group they are assigned, evidently lived, died, and were buried in Catskill conditions and among Catskill species.

The most logical plan is to consider these strata from the base of the red sandstone and shale up to the highest fossiliferous beds above mentioned, or, perhaps, even up to the *Dellville sandstone* (described below), as a series of passage beds between the Chemung and the Catskill during the formation of which Catskill conditions more and more prevailed, rendering the seas less and less congenial to the Chemung fauna, until at length the latter became extinct; and then followed that vast accumulation of red sandstone and shale almost destitute of organic remains, except those

* Which I consider to be *S. disjuncta*.

† See his Reports G⁵, G⁶, G⁷.

of fishes, which is usually recognized as the Catskill formation. The stratigraphical geologist may be disposed to draw a hard line at the base of the red rocks and to say that all above the line shall be Catskill, fossils included. The palæontologist may feel inclined to draw the line at the highest shell-bearing bed and to say that all below the line shall be Chemung, red sandstone and shale included. But neither is a logical sequence from the facts. Passage beds must be expected between all the great formations. The day is near when all the hard lines hitherto drawn across the geological column will be blurred, and system will shade into system as gently as the colors of the rainbow fade into one another. Passage beds even now connect many groups once considered distinct, and the great breaks in life formerly taken to prove total destruction, and recreation of species now only imply migration and remigration caused by secular geographical changes.

This is the view adopted in the following reports. The stratigraphy and palæontology of these shales and sandstones are taken to indicate changes of level and margin in the palæozoic ocean, causing local destruction or migration of the animal population, which returned whenever conditions had become re-adapted to it, or it had adapted itself to them.*

The King's Mill sandstone itself affords evidence of changes of this nature. It indicates beyond question shallow water. The shell-casts so abundant in it at King's Mill and other places are nearly all dead and drifted shells. I have seen few specimens in this bed having the two valves in place. They were evidently heaped up by the waves in masses, thinning off in every direction just as dead shells are now driven and massed together on a beach. Whether this shallow water really indicates a beach at King's Mill, near the commencement of the Catskill area, or a sand bank out at sea, cannot be determined by investigations within the narrow limits of a single county.

On the other hand the fossils found in the shales 500 feet above the King's Mill sandstone indicate that the animals

* These passage beds are colored with the Catskill group on the map.

lived and died where their fossils are found. The shells are perfect, both valves are together, and the internal spiral structure is often well shown. Yet their very small size shows that the conditions of life were not altogether congenial.

The King's Mill shales.

Overlying the King's Mill sandstone is a series of red sandstones and shales, green shales and thin limestones, some of the latter being crowded with fossils mostly in a bad state of preservation in consequence of compression and distortion. Near the middle of the series lie the upper fish beds—two thin layers of scales of the same species as those below the sandstone. *Spirifera disjuncta*, very small, is the only fossil readily identified, the rest being lamelli-branchiate shells, of two or three apparently undescribed species. The limestone bands are crammed with two or three species of small crustaceans (*Beyrichia*.) also apparently new.

The Dellville sandstone.

The fossiliferous series near the base of the Catskill stops at the base of a thick, heavy bed of green sandstone, which is a conspicuous object in several places along Sherman's creek and has served in several places as a barrier confining the stream to its channel. A full account of it will be found in the report on Wheatfield township; but it is proper here to say that it is a double mass of green sandstone, mostly in thin beds, and yielding no fossils except a few indistinct stems. Near the middle of this sandstone is a layer of vegetable matter about an inch thick, consisting almost entirely of *fossil plant stems*, but in so confused and crushed a condition that I have never succeeded in extricating a single recognizable specimen.

This Dellville sandstone I have taken as the base of the proper Catskill in Perry county. It forms a convenient and conspicuous plane of division in the southern part of the county and is probably continuous over the whole district.

May not the Dellville sandstone owe its green color to

the presence of the plant bed in its middle? May not all the beds of green and yellow shale owe their color to the presence of vegetable or animal matter once buried in them? The green Chemung shales often abound with animal remains. The red shales and sandstones of the Catskill may have done the same, but the abundance of iron salts in solution may have destroyed all but the great, solid fish-plates of enamel. The casts and impressions of shells sometimes obtained from the red rocks indicate that life was not wanting in the seas nor its relics in the sediments of that age. The green shales of the Chemung often contain casts showing both the inner and outer marks of the shell on two surfaces. This has probably been caused, as suggested to me by Prof. Whitfield, by the removal of the shell by acidulated water.

The upper beds of the Catskill.

The upper part of the formation consists of harder sandstones, which make a bold ridge round the edge of the outcrop. These beds may be well seen near Duncannon. On the east side of the Susquehanna the N. C. railway has exposed a fine section through them. They continue on the west side forming *Duncannon hill*, a favorite resort for the sake of the beautiful view that can be obtained from its summit. A mile west of this point Sherman's creek passes through this ridge in a very narrow and picturesque gorge.

Thence the sandstone continues under the name of *Pine hill*, forming an outer rampart round the higher and steeper Pocono mountain-wall encircling the cove.

Near the middle of Carroll it returns eastward to the Susquehanna under the name of *The Ridge*. It is here less distinct than on the north side of the trough, the sandstone layers being apparently separated from the Pocono by less soft material.

No. X. Pocono sandstone.

Two V-shaped outcrops of this massive conglomeratic sandstone project into Perry county.

The northern outcrop comes in from Dauphin county just below Liverpool, runs in a straight line to the Juniata, where it returns eastward, as the southern limb of the syncline, to Mt. Patrick. Ledges of rock mark its passage of the Susquehanna at both places. This formation will be described in detail in the reports on Liverpool, Greenwood, Howe, and Buffalo townships.

The southern or Allen's cove will be described in the report on Penn township.

No. XI. Mauch Chunk red shale.

Inside the two coves lie two triangular patches of the Mauch Chunk red shale, the latest of the geological formation now remaining in the county, but as mentioned elsewhere, not the latest that once existed there. Great parts even of this have been swept away, only about 1500 feet remaining. Some of its beds are hard, and form low rounded elevations not deserving the name of hills. But for the most part they are soft and easily eroded.

The red shale in the southern cove is cut by the various dykes described in the report on Penn township.

The lower part of this red shale is very calcareous in some places, sufficiently so at Mt. Patrick to render hard the water in the wells. But there are no limestone bands, still less any indications of that sheet of lower carboniferous limestone which becomes so conspicuous a feature in the geology of the Southern and Western States, and corresponds to the mountain limestone of Europe.

The Volcanic rocks of Perry county.

This title may appear strange at first sight, but it has long been known that in the southeast of the county occur some rocks of very peculiar nature, totally different from any others. They cut across the line of the bedded rocks quite regardless of their direction. They are very heavy, intensely tough, and highly charged with iron. They are in effect what the geologist calls "trap-rocks," what the miner calls "elvans." They are composed of material that has been fused, and forced in a fused condition into and

between the other rocks, filling up cracks and cavities and baking and hardening by its heat the strata through which it flowed. When cooled the fluid matter became hard, and is now known as intrusive or trap-rock.

These trap-rocks of Perry county are but a part of a great system of dykes which traverse the New Red Sandstone rocks of York and Adams counties.

Full details of these trap dykes are given in the reports on Penn and Rye townships, so that it is unnecessary here to do more than call attention to them. One of them appears to cross the Susquehanna, a mass of trap appearing opposite Duncannon in the cutting on the Northern Central railway.

CHAPTER IV.

The Faults of Perry county.

The country lying immediately south of Mahanoy ridge is one of the best collecting grounds in the county for the fossils of the Hamilton and Chemung groups. The upper Hamilton shales are there exposed better than elsewhere, and the Chemung, especially the lower part of the group, may also be examined in many small wayside cuts and field exposures.

This ground has been hitherto supposed and was represented on the preliminary map of the county to be a syncline between Mahanoy Ridge and Nick's hill, bounded by outcropping edges of Hamilton sandstone, the middle of which was occupied by a sheet of Chemung rocks. But a very short examination sufficed to show that the Hamilton upper shale extended much farther out into the valley from Mahanoy ridge than the bounding line drawn on the map.

Hamilton fossils were found farther and farther out from the ridge in the ground represented as Chemung, until it became evident that in the western part of the so-called basin or trough the Hamilton upper shales were repeated by the extension to the eastward of one of the anticlines represented at its west end. (*Crawley Hill* is a mass of Hamilton sandstone rising immediately to the south of the turnpike road running to Little Germany at a point not more than three miles from Bloomfield.) The influence of this anticline is to bring up the Hamilton upper shales again to the surface, so that the lower beds crop out at or near the school-house on the branch road to the south. Along this branch road the Hamilton shales still occupy an immense space, far more than their thickness, and yet they dip steeply.

The Perry county fault

Fig. 1.

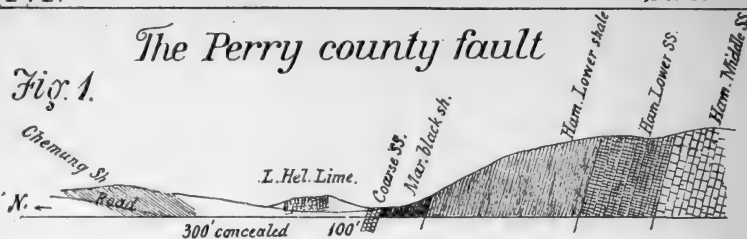


Fig. 2.

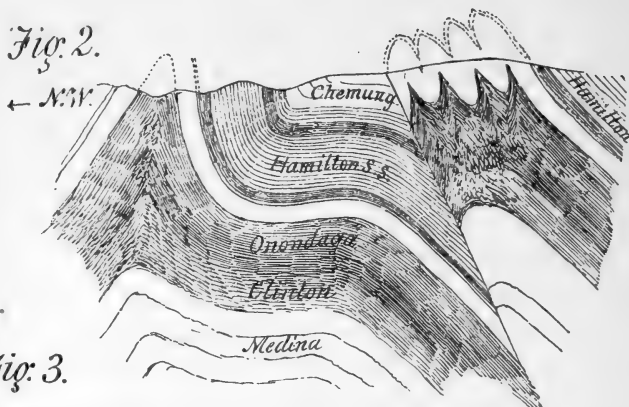


Fig. 3.

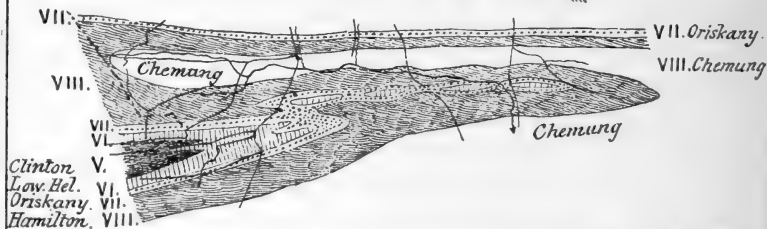


Fig. 4.

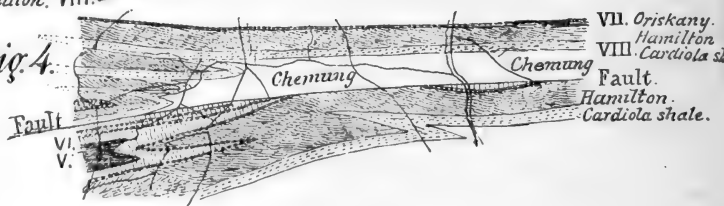


Fig. 1. Cross section of the faulted district.

Fig. 2. Diagrammatic section across the fault.

Fig. 3. Copy from the published map of Perry Co.

Fig. 4. Corrected representation.

Another anticlinal axis, also running up from the southwest produces another repetition of the Hamilton upper shale around the outside of the Hamilton sandstone ridge, inclosing on the east the Perry Furnace valley, so that in passing south about half a mile from the New Bloomfield and Little Germany road one passes over two anticlines; rising first to the top layer of the Upper Hamilton shales or perhaps even into the Genessee; then descending to the edge of the Hamilton sandstone; again rising over the syncline; and again descending on the second anticline. Nor is it until both these ridges have been passed over that one finds the strata regularly dipping outwards at an angle of almost 90° from the last anticlinal axis.

The consequence is that the Chemung rocks do not occur, as they were believed to do, in the west of the valley. The whole of this area is occupied by Hamilton shales.

On the other hand much of the area believed to be occupied by Hamilton rocks between the roads leading to Perry furnace and to Gibson's rock is occupied by beds of later date. Most of them are equivalents of the Genessee, Portage and Chemung, very similar in appearance to one another. In fact among the slight though rather numerous exposures of shale occurring in the valley it would be almost impossible without the assistance of fossil forms to determine their different horizons. Even with this aid the difficulty, although diminished, is not removed. Many of the beds are totally barren; but, by the study of the fossils yielded by others, the folds and varying angles of dip were followed out, and Chemung fossils and rocks were found to occupy the whole southern side of the middle basin close up to the foot of its bounding range, *Dick's hill* and *Iron ridge*. Inasmuch as the base of these hills is in many places occupied by the No. VI limestone, it is evident that strata so far apart can only be brought into contact by a fault.

Following the various roads out of New Bloomfield it is not difficult to trace this fault throughout the county.

1. The Ridge road to Carlisle. On this line the successive formations occur in regular sequence from New Bloomfield

Fig. 1. Section at Half Falls mountain on the Juniata.

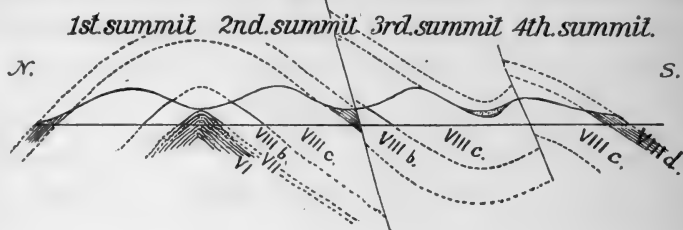


Fig. 2.

Map of the eastern end of the Perry Co. faults.

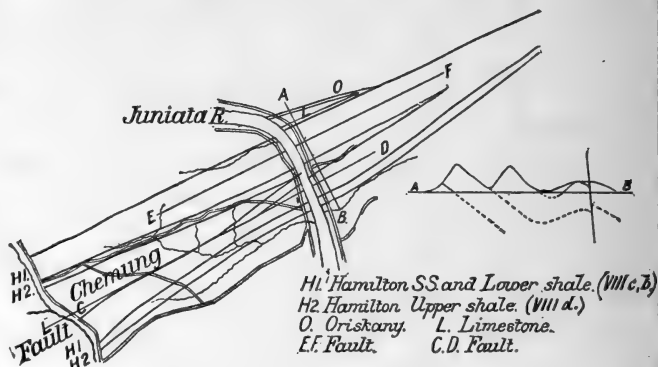
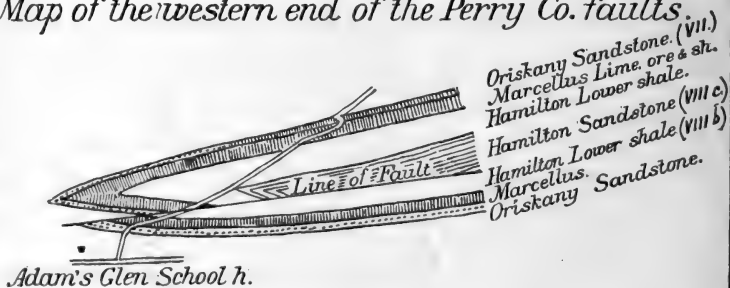


Fig. 3.

Map of the western end of the Perry Co. faults.



for about $2\frac{1}{2}$ miles, when the ground suddenly changes from Chemung shale to No. VI limestone.

2. Old road to Carlisle. The same result is obtained along this line. At about 2 miles from New Bloomfield is a small roadside cutting showing Chemung shale, and at about 100 yards farther on is an indistinct but manifest Oriskany ridge. Between the two is a narrow strip of Lower Helderberg (No. VI) limestone.

3. West road to Gibson's Rock. At about two miles and a half from New Bloomfield the Portage beds (Cardiola shales,) dipping at nearly 90° , crop out on the roadside, and within 100 yards the road passes over the Oriskany sandstone near Mr. S. Brown's house.

4. Road to Montebello narrows. This road running almost due east passes over a great distance of Chemung shales, rising to a higher horizon than either of the roads already mentioned. But on turning to the south at the entrance to the narrows two cuttings, only 150 yards apart, show the one Chemung shales and the other Lower Helderberg limestone.

5. Road from Perry furnace to Gibson's rock. The old Perry furnace lies upon the Lower Helderberg limestone. The Oriskany sandstone does not make any conspicuous ridge along this road. But at a few hundred feet south of the furnace the base of the Hamilton sandstone is seen, and passing through the narrows its upper limit may be easily detected. Following this, at a distance of about 400 feet comes in the Oriskany sandstone, forming a distinct ridge of rocks. The fault, therefore, comes through in this interval, bringing *Lower Helderberg limestone in contact with Hamilton upper shale.*

The throw here is less than further east, not exceeding 1650 feet, measured at right angles to the beds, or 2300 feet if measured vertically.

6. Road to Losh's run, (Polecat road and Ohio wharf road.) This road strikes the line of fault about 6 miles east from New Bloomfield. The exposures are not quite so striking as in the places already mentioned, but the fault is quite as conspicuous. Chemung shales occupy the ground

south from Mahanoy ridge to Dick's hill, with, so far as can be determined, a tolerably uniform dip of about 40°. Close to the northern foot of Dick's hill the Lower Helderberg limestone is quarried. Though no cutting showing the shales can be seen close to the quarry, yet the surface of the fields shows the presence of the Chemung sandstone; and from the color it is apparently nearer the top than the bottom of the group. Some indications also are present which seem to show that the yellow shales and brown sandstones underlying the L. Helderberg limestone are brought up into contact with the Chemung.

The *throw of the fault* here is consequently greater than at any one of its western exposures, amounting, if measured square across the beds, to about 4650 feet, or *vertically* 6510 feet.

Westward from these localities followed the fault may be traced. It cuts off the Hamilton sandstone of South Furnace ridge, which declines in consequence to the general level of the country. This extinction of the Hamilton sandstone ridge takes place about two miles southwest of the Perry furnace. It cuts through the Oriskany ridge almost at the point where the two outcrops are about to meet, and passing out of the Oriskany near the high point behind Adams' Glen school-house (near Landisburg) cannot be followed through the monotonous red shale of which the valley consists. There is, however, no ground for supposing that it continues into the Blue mountain, no traces of displacement being visible in Kennedy's valley or on Pilot Knob.

Eastward beyond the exposure near Montebello narrows, described above, the fault continues, but its investigation becomes difficult. After leaving the exposure at No. 6, which is about a mile east of the narrows, and where the throw is greatest, it suddenly diminishes. The Hamilton sandstone, which has been faulted up and has formed the monoclinical ridge of Dick's hill, suddenly sinks and vanishes underground. The land being low it is not easy to find evidence of its presence, but sections along the river and in Watts township show that it continues to Half Falls mountain.

From the facts that have been collected the only possible inference is that the fault here doubles itself and rapidly diminishes. The line already traced continues nearly along the course of Losh's run and forms the most southern of the four ranges of Hamilton sandstone which together form Half Falls mountain.

Near the meridian line on which the sudden descent of the Hamilton sandstone takes place and Dick's hill disappears, a subsidiary fault develops itself about half a mile northward near the end of Mahanoy ridge and continues to and across the river where it throws up a second ridge of Hamilton sandstone immediately south of the first and nearly equaling it in height. (See below, and report on Watts township.)

The Perry county fault is thus shown to be one of no trifling extent, having been traced about 18 miles from E. N. E. to W. S. W. The changes which it renders necessary in the State map are considerable. The whole north dipping outcrop of Hamilton sandstone supposed to range along the north side of Dick's hill must be cancelled, and its place occupied by south dipping Chemung shales. The supposed Chemung shales in the western end of the valley must be replaced by Hamilton, and the supposed Hamilton by Chemung. These changes may be seen in a moment by comparing the two sketch maps on page plate VI, Figs. 3 and 4, with one another. The narrow middle valley of Perry county is not a syncline but a monocline. Half of it has been elevated above the level of the rest, removed by atmospheric action and swept into the Atlantic, leaving the monoclinical south dipping half of the Dick's hill anticline as a monument of its former existence.

The section through Montebello Narrows five miles east of New Bloomfield (see page plate VI, fig. 1) and that south of New Bloomfield, although not drawn accurately to scale, will suffice to show the amount of throw and the horizons brought into juxtaposition, which vary to some extent, but these variations do not in any way affect the general truth.

The fault is indicated on the surface only by a slight and interrupted depression not in any way noticeable; but

along at least a part of its course it is marked by a line of strong springs. So evident is it when the structure of the county is understood that a man can stand with one foot on the Chemung shales and the other on the Lower Helderberg limestone.

In estimating the throw of this fault it must be remembered that it is not everywhere of the same extent. At its greatest the olive shales of No. VIII, the Chemung, are brought into contact with the limestone of No. VI, the Lower Helderberg. If we then calculate the throw where it is greatest we shall get the following results. The part of the Chemung appearing at the surface at the fault is as near as I can ascertain about 1800 feet above the base of that group.

Partial thickness of Chemung, (lower portion,)		1800 feet.
Total	" Portage,	200 "
"	" Genessee shale,	200 "
"	" Hamilton Upper shale,	300 "
"	" Hamilton sandstone,	600 "
"	" Lower Hamilton shale,	500 "
"	" Marcellus black shale,	100 "
"	" " limestone and shale,	100 "
"	" Oriskany sandstone,	25 "
Partial	" Lower Helderberg limestone and shale,	250 "
Total thickness of rocks thrown by the fault,		<u>4075</u> "

Thus within certain small limits of error is the amount of throw calculated at right angles to the bedding. The total dislocation is however much greater. The tangential or horizontal thrust, to which is due the folding of the Appalachian strata and their accompanying or subsequent fracture, forced the rocks on the southeast side of the fault over those on the northwest side along a slope whose angle cannot be determined. It has been represented in the section as 45° but was probably less. If the amount above given be now increased in the proportion of the sine of this angle to the radius, or multiplied by 1.4, we obtain as the actual displacement of the strata, at this part of the fault, about 5700 feet.

The Half Falls fault.

This fault is apparently confined almost wholly to the

Hamilton sandstone. It begins near the east end of Mahanoy ridge. Its most conspicuous effect is to throw up the sandstone after it has sunk on the south side of the anticline and so cause a repetition of its whole thickness. The result of this and the Perry county faults where they cross the river is in combination with the anticline to give the mountain four separate summits, and to produce a tract among the wildest in the county, which gradually narrows eastward by the convergence of the ranges and dies away at Girty's Notch on the Susquehanna.

The throw of this fault does not exceed 600 or 700 feet, and its maximum is apparently on the river. It probably ranges east and west about 3 or 4 miles, but it has been impossible to trace it away from the Juniata.

The Little Germany fault.

This fault runs parallel to and at the distance of about a mile north of the long Perry county fault.

It develops itself near the hamlet of Little Germany in Spring township and runs east northeast into Centre for nearly five miles. Though far inferior in length and throw to the Perry county fault it yet produces much complication in the geology and several noteworthy changes in the topography and landscape.

The most westerly point at which I have been able to detect the fault is on the hill west of Little Germany, where it produces a fork in the Oriskany sandstone; one ridge continuing on its previous course; the other diverges slightly to the southward. The latter thrown up by the fault is cut off at a short distance, the ridge terminating in a field.

In thus bringing up the Oriskany to the surface the dislocation has also brought up the Lower Helderberg limestone adjoining it, and the result is that the limestone has been quarried and burnt at one place at the distance of only about one hundred feet south of and therefore apparently *above* the Marcellus black shale, with no intervening sandstone ridge. The Marcellus thus occurs on *both* sides of the narrow belt of limestone.

A little farther to the east we find the Lower Hamilton shale brought up on the south side against the Marcellus on the north ; and farther on, the lower shale, about 500 feet thick, occupies both sides of the fault.

As we approach the township line which lies on the watershed, parting the south fork of Montour run from the tributary of the Little Juniata, a high connecting ridge of Lower Hamilton shales rises on the south side of the fault, exposing the Marcellus at its base into which a tunnel (six feet square in section) has been driven in search of coal.

On the north side lies the Hamilton sandstone, through which the fault here cuts obliquely, causing a lateral displacement of nearly a mile, through which the road passes from the lower to the upper shale without crossing any sandstone ridge.

Entering Centre township the fault passes along the strata as they rise to the Crawley arch, leaving the synclinal west end of Mahanoy ridge separated from the anticlinal east end of Crawley hill. The latter is so far eroded as to expose the Hamilton lower shale for more than two miles from Little Germany.

The throw is greatest near the watershed on the township line where the lower part of the Lower Hamilton shale is brought up against the Upper Hamilton shale, and may be estimated thus :

Upper Hamilton shale, (part,)	150 feet.
Hamilton sandstone,	600 "
Lower Hamilton shale,	400 "
	<hr/>
	1150 "
	<hr/>

But as the beds dip at about 45° the actual vertical displacement is more, being in proportion to the size of the angle of dip. This will give about 1600 feet.

The fault extends into Centre township almost to Bloomfield, gradually dying out. But it may be traced by a slight valley and by the increased thickness of the Hamilton upper shale as far, at least, as the residence of Mr. William Brunner. Its total length is about four and a half miles.

Intermediate fault.

A third fault of small dimensions runs between the two above described.

Beginning near the house of Mr. George Meck it causes a repetition of the Hamilton sandstone, bringing the middle and upper beds to the surface after they have dipped south from the Crawley anticline.

This fault is of no great extent apparently disappearing in a mile and a half. Nor is its throw more than about 200 or 300 feet. But it makes a distinct short ridge of Hamilton sandstone and a deep intervening valley between it and Crawley hill.

Fig. 1.

Section across Limestone ridge S. of Newport.

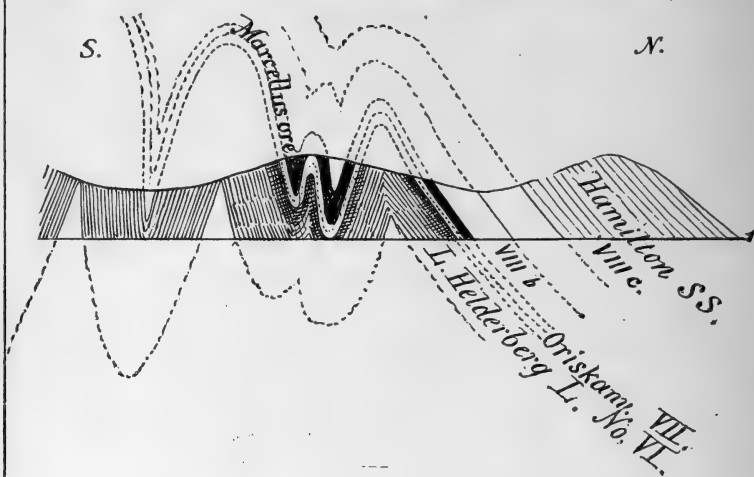
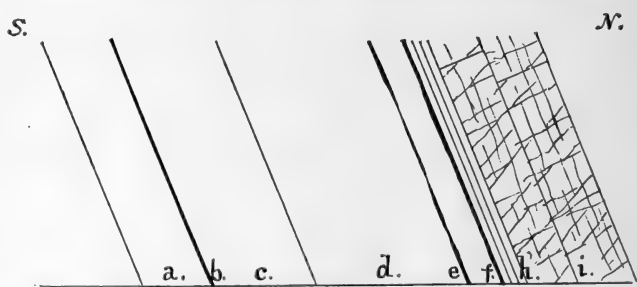


Fig. 2.

Section at mouth of tunnel, Mt. Patrick.



Dip 65° N.

CHAPTER V.

The Iron Ore, Limestone, and Coal of Perry county.

Iron ore occurs on three distinct horizons in Perry county, exclusive of several which have never yet yielded it in paying quantity. These will be described in their geological order from below upwards.

1. The Clinton fossil ore beds.

The first or lowest and oldest of these horizons is that of the Millerstown beds. This ore occurs above the middle of the Clinton group, and is both from its quality and its locality the most valuable ore in the county. The only drawback is the thinness of the bed which necessitates the removal of some of the rock in order to obtain room for working. The outcrop near Millerstown is close to the river, canal, and railway, so that the means of transport are as convenient as possible.

The lowest of these Millerstown beds is what is called the *block ore*. This is in reality the lowest layer of the iron sandstone. The iron sandstone is thin in the north of the county, and for the most part contains little iron, but toward the base it becomes richer, and at last yields a bed softer than the sandstone, but harder than the other ores of the district, which breaks out in roughly cubical blocks, whence it derives its name.

With it there occurs a red sandstone bed, forming a complete mass of flattened pebbles of red shale in a sandstone matrix. This ore bed is not now taken out.

Above this hard fossil block ore bed lies the *Iron sandstone*, here about ten feet thick. Then follow about 200 feet or more of green shales not well exposed at Millerstown.

On these lies the second bed of fossil ore about a foot or rather more in thickness, capped by the thin *upper iron sandstone*.

A hundred and sixty feet of shale, mostly greenish, overlies this, and are in turn overlain by the *ore sandrock*, a double bed of sandstone about ten feet thick, containing between its two portions a thin bed of hard ore.

Upon the sandrock lies the great source of all the Millerstown ore, the *sand vein ore bed*, about twelve inches thick.

The mining industry at Millerstown is of comparatively recent date, little having been taken out before 1866. I have been told, however, that a small quantity was used at the old Juniata furnace more than 40 years ago. Since then, however, several hundred thousand tons have been sent to Reading, Harrisburg, Dry Valley, and Lochiel where it takes high rank among iron ores. It is said to yield a very tough iron.

One fact connected with these beds is well known by all engaged in mining or seeking ore, because it has a most important influence upon the quantity that can be obtained in any given area. The fossil ore is only soft to a certain depth, or to the depth to which the surface water penetrates. Below that it is a hard ferriferous limestone, useless for the furnace. In the slopes of the mountains, where the drainage soaks down, the hard limestone—the original ore-bed—has been altered by the removal of the lime and perhaps by the concentration of iron, so that its texture is softened and its proportion of ore relatively, if not absolutely, increased and it is rendered valuable as an ore. But below this level, and probably in most of the flat land, nothing would be found but the hard limestone above mentioned. This fact is sometimes overlooked in estimating the quantity of iron ore and the consequent value of the land containing or supposed to contain it. In fact the sand vein ore bed and the other underlying fossil ore beds are in all probability nearly worthless, except along the slope of the ridge where they crop out. Even there, in some places, the hard, limestone is found. Mr. R. Cochran has recently cut it in a drift opened about a mile west from Millerstown and where the expense of mining far exceeds the value of the ore.

A determination of the principal ingredients of the hard

limestone ore by Mr. A. S. McCreath has given the following results:

Analysis of hard fossil limestone ore, one mile west of river at Millerstown.

Iron,	5.640
Phosphorus, . . . . .	.065
Lime,	41.730=74.518 Carb. of Lime.
Siliceous matter,	10.880

Extent of these Beds.—As regards the extent of these Millerstown ore beds over Perry county little that is definite can at present be said. The value of ore in the west, far from a railway, is so small that there is little inducement to search for it. These three beds certainly make no conspicuous show anywhere except near Millerstown. Traces of soft fossil ore were shown to me in the neighborhood of Marysville by Mr. A. Seidel, and the hard ferriferous limestone is reported on Bowers' mountain and perhaps in one or two other places in the southwest. But in others there are no indications of either the soft or hard ore, and the section given in the report on Toboyne township is conclusive against their existence at that place. There is, however, ample room for them in places not yet examined where the ground is covered with wood or uncultivated, for there is little prospect of finding surface indications of so soft an ore except through the plow.

The Sand Vein Ore Bed.—This bed, as may be seen from the section at Millerstown already given, is the highest of all those occurring there and is separated from the others by the ore sand rock and shales. Like them it is thin, seldom exceeding fourteen inches in thickness, but so far as I have been able to examine the ground it is much more persistent over the county. Its quality is good, as the following analysis by Mr. A. S. McCreath will show, the proportion of phosphorus being, however, rather high. The specimen came from the mine of Messrs. B. G. Mush & Co. on the southeast side of Tuscarora mountain, one fourth of a mile north of Millerstown: *

* See Report M³, 1881, page 37.

	(117)	(118)
Sesquioxide of iron,	78.571	73.714
“ “ manganese, . . . . .	.021	.021
Alumina,	4.927	5.702
Lime, . . . . .	.510	.390
Magnesia, . . . . .	.213	.209
Sulphuric acid, . . . . .	.042	.050
Phosphoric acid,	1.502	1.784
Water and organic matter,	6.015	9.075
Siliceous matter,	8.170	8.870
	<u>99.971</u>	<u>99.815</u>
Metallic iron,	55.000	51.600
Metallic manganese, . . . . .	.015	.015
Sulphur, . . . . .	.016	.020
Phosphorus, . . . . .	.656	.779
Phosphorus in 100 parts iron,	1.192	1.509

This bed is mined at and near Millerstown, but nowhere else in Perry county, though indications of its presence are not wanting in many other parts. It apparently accompanies the ore sandrock in its various outcrops, and shows itself in the valleys in the west. In Kennedy's valley especially there is unquestionably an abundant supply of rich ore along the ridges near the face of the sandrock. All this is however a store for the future, since it is in the present state of transportation valueless.

Further details concerning these Clinton ore beds will be found in the report on Greenwood and Tuscarora townships.

2. *The Marcellus brown hematite.*

The second iron-bearing horizon in Perry county lies at the base of the Marcellus black shale and on the top of what has sometimes been regarded as the representative of the Corniferous limestone of New York, but what I consider only a calcareous bed belonging to the Marcellus.*

This ore is not a fossil ore like that at Millerstown, but a concretionary limonite,† called locally a wash ore, because occurring as it does in a bed of clay it needs washing to fit it for the furnace. Its form is usually pseudo-stalactitic, lying in horizontal masses with stalactitic appearance. It is

* It is extensively mined on the Juniata in Mifflin county, on Yellow creek in Bedford county, and elsewhere.

† i. e. brown hematite.

often hollow, and is hence called "pipe ore." Sometimes it is more cellular, when it is termed "honeycomb ore."

This is, or rather has been, the most extensively worked ore in the county. Its outcrop follows the outcrop line of the Oriskany sandstone throughout its zigzag course, being seldom entirely absent. At the same time its thickness is very variable, ranging from 12 or 14 feet down to one or two feet in no great distance. This renders the mining uncertain and hazardous. It is worthy of notice that where the ore attains its greatest thickness, the accompanying limestone is absent, and the ore with its inclosing white and black clay lies on the Oriskany sandstone. This may be seen at the Clouser works south of Newport; at the Reeder works northeast of Bloomfield, and at the Long works three miles west of Bloomfield. When the limestone and its lime shales reappear, the ore thins down.

At the Clouser works, where it can be best seen, the ore occurs in two or three beds with intervening strings all massed in a white clay. The whole is taken out and washed together. The thickness of the mass is at the least 15 or 20 feet. No trace of the limestone is visible on either side of the ore, which here lies in a syncline of the Oriskany, containing a small secondary fold which largely increases the accessible amount of ore. The structure of limestone ridge at this place is shown on Page Plate VIII, Fig. 1.

The Marcellus ore has been mined at the following (with other) places in Perry county:

(1.) Limestone ridge.

The Clouser works, south of Newport.

The Reeder works, near old Juniata furnace

One mile north of New Bloomfield.

(2.) Iron ridge.

Half a mile south of the old Perry furnace

Half a mile west " " " "

(3.) Mahanoy ridge.

At New Bloomfield.

Three miles west of New Bloomfield.

Four miles " " "

(4.) Near Little Germany.

Southwest of Little Germany, in Bell's hill.

North of Little Germany.

(5.) Pisgah hills.

Half a mile southwest of Oakgrove furnace.

(6.) Above Adams' Glen school-house, near Landisburg.

The above list does not include all the places where iron ore has been taken from the Marcellus hematite bed, but these are given to show its general distribution over the county. In other places—as near Gibson's rock—there is no sign of its presence in the usual place. Any one will be able to discover by reference to the map accompanying this report the place where its outcrop should be looked for along the line which separates the Oriskany sandstone and the Marcellus black shale.

At the present time, 1883, owing to the low price of iron ore (at the only furnaces now in blast in the county—Duncannon and Newport—about \$3 a ton,) this bed of ore is mined at only the two most favorably situated places in the county, the Clauser and Reeder works, from both of which it is sent to Newport. The roads from these points are short, and no ridges intervene. Where these advantages are not present the mining is now attended with loss, consequently all the other works have been abandoned.

As in the case of the soft Millerstown fossil, so also in the case of this ore a great change takes place below the access of surface water. Down to that level the ore is a loose hematite—a wash ore—bedded in clay. Below that it is a hard blue carbonate of iron, heavy and massive. As this ore needs roasting at the furnace to expel the carbonic acid before it can be smelted, it is of course less valuable, and less is paid for it. It is therefore not worth following to the deep, and no attempt is usually made to take it out in Perry county.

The following analyses, by Mr. A. S. McCreath, of samples from the Clauser works, two miles south of Newport, represent the value of this ore and its variation :*

* See Report M³, page 32, where other analyses will also be found.

Sesquioxide of iron,	50.285	61.143	62.000
“ “ manganese, . . . . .	.051	.072	.072
Alumina,	5.101	2.937	4.191
Lime,	1.070	.650	.600
Magnesia, . . . . .	.342	.288	.324
Sulphuric acid,	trace.	.107	.135
Phosphoric acid, . . . . .	.146	.176	.279
Water and organic matter,	7.465	9.980	9.925
Siliceous matter,	35.540	24.640	22.570
	<u>100.000</u>	<u>99.993</u>	<u>100.096</u>
Metallic iron,	35.200	42.800	43.400
Metallic manganese, . . . . .	.035	.050	.050
Sulphur,	trace.	.043	.054
Phosphorus, . . . . .	.064	.077	.122
Phosphorus in 100 parts iron, . . . . .	.181	.179	.281

3. *The Hamilton (Montebello) fossil ore.*

This ore, which ranks third in the county for value and productiveness, lies on the top of the Hamilton sandstone; and its outcrop, more or less ferruginous, follows the outcrop of that bed through the county. It is usually about two feet thick. In the lower part where in contact with the rock it is very sandy and fossiliferous. In the upper part it is a fairly good hematite. Both parts are usually taken out together.

Most of the ore taken from this bed has been used at Duncannon furnace for mixture with better ores. Some, however, was mined near the old Perry furnace and smelted there, many years ago, with ore brought from Catawissa.

The line of outcrop of this ore may be traced across the county by any one who wishes to do it by following the line between the Hamilton sandstone and the Hamilton upper shale, on which horizon it will always be found if present. It varies much in thickness, as do the other orebeds, sometimes thinning down to almost nothing.

Little or no appearance of the Hamilton fossil ore is to be seen in the northeast of the county, where the Hamilton sandstone slopes down from the Tuscarora anticline along Pfoutz's valley. Nor have I observed or heard of its occurrence along the whole line of outcrop thence to Sandy hill. But it begins to show itself on the south side of the

Buffalo Mountain syncline; and near Manorsville it has been mined under cover for some distance, but the roof of the opening has fallen in.

From this point east it may be traced by openings on it in several places—near the old Juniata furnace on Inoculate run; again south of Newport; and at Gerty's Notch on the Susquehanna river, where it was mined by the Messrs. McCormick.

Returning along the south side of Half Falls mountain to the Juniata, where several hundred tons were once taken out, it follows the south side of Mahanoy ridge and has been dug on the farms of Messrs. Cook and Petermann. It makes a small show near New Bloomfield; but west of that town it seems to be absent; nor do we find it again until it reappears on the south side of Crawley hill near the school-house north of the Perry furnace. Here it is fair in quality and quantity and has been mined to some extent.

From here to where it is cut off by the fault it does not appear, but on the other side of the fault in Wheatfield township on the south side of Dick's hill it is found again, better in quality and quantity, on the farms of Messrs. Dachterman, Lickel, and Rathvon. It was mined here some years ago by the Duncannon Iron Company. Here the bed is double, or even triple, part of the Hamilton upper shale becoming ferruginous. See report on Wheatfield township.

Thence southwestward along the south side of Pisgah hill it makes but slight show, but reappears in full force along the north slope of Little mountain, as the Hamilton sandstone returns along the other side of the Oak Grove (Stony creek) syncline toward the Susquehanna river.

Here it has been opened at several places, chiefly by the Messrs. Seidel, of Marysville, and appears to be thicker and better than anywhere else in the county.

I have observed no signs of any changes below drainage level such as were mentioned in the reviews of the other iron ores of Perry county, and it is probable that this ore continues unchanged to greater depths. But the large amount of lime it exhibits near Marysville suggests the possibility of its passing like the others into a ferriferous

limestone. At the present time, however, no ore is taken from this bed. Distance from furnace and cost of carriage combine with low prices to render mining in the Hamilton fossil ore an unprofitable pursuit.

Oriskany ferruginous beds.

Iron ore also occurs at several other horizons in the county, but on none so far as I have been able to learn in quantity that offers any hope of profitable working.

A hard siliceous ore occurs near or at the top of the Oriskany sandstone, but is of no value. It often misleads farmers by inducing them to think that a valuable bed of ore exists, but all labor in seeking it is thrown away. Northeast of Blain the Oriskany sandstone itself is very ferruginous.

Near Gibson's rock on the land of Mr. H. Smith, and also on that of Mr. Gibson, this ore exists, and has been dug out and ground for ocher. It is said to yield a base of good quality for mixing paints, and has been used to some extent for that purpose. It also makes some show near Bixler's mill, in Madison township.

Portage-Chemung iron ore.

A deposit of liver-colored ore has been observed at one place on the land of Mr. S. Brown between Newport and New Bloomfield. It lies on the top of the Portage-Chemung sandstone, is at this place of good thickness, but its quality is doubtful. It certainly does not extend far, as there is no sign of it in the same situation a mile away. An examination by Mr. McCreath shows that it is a lean ore, and utterly worthless.

Catskill iron ore.

A seam or perhaps several seams of red specular hematite of good weight and excellent quality may be found traversing the Catskill rocks in several parts of the county, especially in the southern or Oakgrove syncline. Its yield of iron is shown in the appended analysis by Mr. A. S. McCreath:

Sesquioxide of iron,	86.000
Sesquioxide of manganese, . . . . .	.072
Alumina,	1.848
Lime, . . . . .	.750
Magnesia, . . . . .	.403
Sulphuric acid, . . . . .	.040
Phosphoric acid, . . . . .	.082
Water and organic matter, . . . . .	.975
Siliceous matter,	9.830
	<hr/>
	100.000
	<hr/>
Metallic iron,	60.200
“ manganese, . . . . .	.050
Sulphur, . . . . .	.016
Phosphorus, . . . . .	.036
Phosphorus, in 100 parts iron, . . . . .	.059

Unfortunately, however, this ore occurs only in thin seams seldom or never exceeding four inches in thickness, and flanked with hard sandstone. Both these reasons combine to render its extraction unprofitable.

Pocono iron ore.

It is not likely that beds of good iron ore exist in the sandstone of Peter's and Cove mountains, and in Buffalo and Berry's mountains. Until iron becomes much more valuable than it is at present, or is likely to be for many years to come, it is not probable that any labor or money will be spent in the search. It is impossible, therefore, to say anything at present about their value or extent.

The charcoal furnaces in Perry county were blown out about 1840-45, and have never since been relighted, the substitution of coal and coke for charcoal in the process of iron-smelting having been here as in other places the means of removing the iron manufacture from its old seat to places nearer or more accessible to the coal fields. All the iron now smelted in Perry county is smelted in furnaces on the line of the Pennsylvania railway.

The principal points to be considered in mining are:—

- 1st. Thickness of ore bed.
- 2d. Quality of ore or yield of iron.
- 3d. Freedom from gangue of clay or sand.
- 4th. Freedom from partings of shale or clay.

5th. Supply of water for washing the ore if necessary.

6th. Quality of the iron—freedom from phosphorus.

7th. Suitability of the ore for the smelting process.

8th. Distance from the furnaces—cost of hauling.

9th. Price of the ore delivered at the furnaces.

No ore bed in Perry county now fulfills all these conditions sufficiently to yield much profit to those who work it.

Lime and its use upon land.

The only minerals of commercial value yet discovered in this county are limestone and iron ore. The former is almost confined to the Limestone ridge and other outcrops of of the Lewistown limestone.

Immense quantities of stone have been taken from different parts of Limestone ridge, largely as a flux when the furnaces were in blast, and since then for liming land, for which it is well suited.

All the limestone in the county is low in magnesia, much almost a pure carbonate of lime. It yields consequently a "hot" or "fat" lime, less convenient for the purposes of the builder than the "cool" "lean" lime derived from the dolomitic limestones of other places. It slakes soft, and crumbles down to powder, showing that it possesses little or no hydraulic properties, and therefore is low in alumina.

No hydraulic limestones or cement beds are worked in this county, and, so far as I have learned, none have ever been found there. Attempts have been made to burn some of the calcareous shales at the base of the black shale for this purpose, but without success.

The vexed question of the advantages and disadvantages of liming land has not been solved in Perry county. Both sides have strong advocates. Men who have persistently limed the black shaly land for many years maintain that it has much improved under the treatment. But the general disuse of lime of late in the county is an argument on the other side. Probably both views would be considerably modified if all the concomitant circumstances were taken into the account. The experience of farmers in this region

supplies no new argument against the position now taken by most agricultural chemists that lime is a stimulant, and not an enricher of the soil. If the soil contains nutritive material the lime can render that material more readily available; and in this way it is advantageous to land where stores of plant-food are locked up. But if the land contains no such store the addition of lime can never bring forth any. Limestone soils are as much improved by the addition of lime as are the shaly soils, whether black or red, because the lime applied is in a very different chemical condition from that which naturally exists there. The unburnt lime of the soil is quite inert as a decomposer of plant-food; but when burnt and rendered caustic its decomposing energy is developed. In the stone the lime is combined with carbonic acid, which completely masks the active property on which its value as a stimulant to the soil depends. But in the kiln this carbonic acid is driven off, the stone loses about half its weight, and its power of decomposing organic matter is developed.

For the same reason a limestone soil, as it is called, if it really contains any lime, contains it in the same form, the carbonate. Hence the lime, if naturally present in the soil, is of no value as a stimulant; it is inert; and the addition of quick or caustic lime has exactly the same effect both in nature and amount as on any other land.

The secret of the value of lime in agriculture lies in the chemical fact already alluded to, that quick or caustic lime has the power of decomposing animal and vegetable matter. Hence lime *in this caustic state* speedily destroys organic material and reduces it to a condition in which it is available for plant-food. But it is obvious that the amount of plant-food thus produced will depend on the amount of organic matter existing naturally in every soil, and unless this store is in some way replenished it must before long become exhausted.

The liming of land therefore year after year without the application of manure of some kind must end in the reduction of the natural store of plant-food below that which will yield a paying crop, as is the case with not a little of the

poorer sort of land in Perry county at the present time. Some of the farmers are in the condition of men who possess an annuity, but overdraw it every year, thus reducing the principal, dollar by dollar, until it falls too low to afford them a living.

An intelligent farmer aided by a knowledge of the chemical principle above laid down, will see that he can only secure an advantage from lime by placing in the ground a supply of organic material which the lime will convert into plant-food. This supply may be obtained by manuring it; by allowing it to lie fallow, when the weeds which spring up and die will add their remains to the soil; or, by growing some green crop upon it, such as clover, the tops and especially the roots of which contribute largely to its stock of organic material. (A crop of red clover is said to yield about 8 tons of roots.) This is attacked by the lime, when added, and quickly decomposed, whereas naturally the process would require a much longer time. Hence liming the soil does not really add anything to its fertility, but only anticipates the future and brings back to the farmer in one or two years what would be otherwise spread over more.

The farmer should also bear in mind the fact that quicklime, when exposed to the air, rapidly absorbs from it carbonic acid, and returns to its former condition of carbonate of lime, when it is of little or no use to the land.

Lime should be applied fresh; for, a heap of burnt lime left in the open air rapidly recarbonates itself and loses most of its value. If it cannot be spread at once, it should be well covered with earth to prevent the absorption of carbonic acid. A few drops of muriatic acid (or spirits of salt) if added to carbonate of lime, will cause strong effervescence or bubbling, owing to the escape of the gas, whereas, if added to quicklime, little or no effervescence will ensue. In this way the good or bad condition of a stack of slaked lime may readily be determined.

The use of lime does not, however, altogether end here. In some parts of Perry county, especially those which lie upon the red sandstones of the Catskill group, the soil and sub-soil contain a considerable quantity of *potash* in the

form of silicate of potash. When lime is added to such soil as this, it changes the silicate of potash into silicate of lime, and sets free the potash, which is carbonated. *Carbonate of potash* is one of the most valuable materials for growing plants. Such soils contain within themselves a reserve of this plant-food locked up which ages cannot exhaust. It must not, however, be inferred from the above-stated fact, that this red sandstone soil does not need manure. Plants cannot live or grow upon potash alone, though potash is one of their most important constituents. They require many other chemical elements, which must be supplied in the shape of manure.

Again, when new boggy land is broken up, the soil is often *sour* from the presence of *humic acid* produced by the decay of vegetable matter. In some cases it is too sour to allow the growth of anything but the natural swamp grasses and sedges. Lime is alkaline or anti-acid in property, and, therefore, its application in considerable quantity is productive of immediate benefit in diminishing the acidity and rendering the soil suitable for the growth of more profitable crops.

As to the details of the application of lime, the time, manner, quantity, &c., experience is the best guide, and the farmer can determine these points for himself. But a knowledge of the chemical principles above given will guide an intelligent man in the use of this valuable but much abused stimulant, which, like many others when used alone and unwisely, develops a short-lived energy, but ends in greater exhaustion.

From what has been said, it is evident that the addition to the land of finely-powdered limestone is totally useless as a substitute for quick-liming. It may have a good mechanical effect on some soils, like that produced by sand, coal, ashes, &c., but cannot stimulate their fertility.

The Coal of Perry county.

I have been many times asked during my travels in Perry county if there is not ground for anticipating the discovery

of coal within its limits. Many people are evidently of opinion that coal ought to be found here, because it is found in adjoining counties. Others are of the opinion that the hills of Perry county must contain coal or some other mineral because they are good for little or nothing else.

As to the first argument, I may say that it is quite worthless, unless regard is paid to the position and arrangement of the strata. A miner of gold, silver, lead, or of any other metal that occurs in *veins*, may have ground for believing that the same lode which traverses his neighbor's land must also traverse his own, if it lies in the direction of the lode. But the miner of coal and iron, or of any mineral *deposited in beds*, has no right to anticipate a similar result unless the strata be horizontal, or nearly so. I need hardly, therefore, say that the argument is worth nothing in Perry and adjoining counties where it would be difficult to find a square mile of horizontal strata.

In reply to the second argument, I see no reason for believing that mountains must yield valuable minerals because they are good for nothing else. They may be good for something of which the miner has no conception—scenery, for example. Many of the mountains of the globe have no other value than this. They are safe from the intrusion of cultivation, and in years to come they may be the only parts of the world that are so. It is some pleasure to feel that there are places where Nature will probably remain forever supreme, the solitude never be broken by traffic and commerce, and the soil continue unprofaned by the plow and the harrow. And mountains preserve forests, and influence the climate.

My answer to the question has usually been this: "If by *coal* is meant merely samples of coal, there are enough in Perry county; but if workable, profitable coal seams are meant, then there is none."

The oldest rocks in Perry county lie in the Horse valley, and consist of dark, almost black shales. They have naturally produced the impression that coal might be found there, and Mr. J. Hockenberry showed me a place from which he had taken some. But it was only a very thin seam of in-

ferior quality, absolutely worthless as a coal bed. It pitched, moreover, almost vertically down into the ground, so that to follow it would be difficult and expensive. These shales lie far below all the other rocks of the county; about four miles deep in the Cove.

The next rock in age in the county is the gray shale-slate, also found in the Horse valley; and following this comes the heavy sandstones of the Tuscarora and other mountain ranges. In neither of these has any sign of coal been seen in Perry county, so far as I am aware. The same is true of the great red shales of the western part of the county and of the limestone and sandstone which overlie them and form the summit of Limestone and other ridges in the county.

This brings us in the series of formations up to the *Oriskany sandstone* No. VII; on top of which lie the *black Marcellus slate* beds; and the dark color of these has in many cases led sanguine land owners and "practical miners" to dig at great expense in search of coal; near Laurel Grove, for example.

However some beds of these shales may resemble coal, even to the extent of being "burnable," they are not coal, and have never yielded coal in any places where the search has been made, either in Perry county or outside of it. And as they have been thoroughly examined, the inference is justifiable that they never will yield any.

Upon the black Marcellus shale rests a great mass of olive colored shales and sandstones, about a mile and a half thick, in Middle ridge, Buffalo hills, and many other places. At several levels in this mass of rocks beds may be found, occasionally several inches thick, containing combustible material fairly entitled to the name of coal. But it is usually of a crumbling nature. Several of these thin coal seams may be traced across the Juniata river and crop out in its banks.

As in the cases already mentioned, this has led to various attempts to open mines of coal, all of which have ended in loss and disappointment, not only in Perry county, but elsewhere. For this reason geologists infer that the search for coal in these Lower and Middle Devonian shales and

sandstones will be as unsuccessful in the future as it has been in the past, and dissuade those who consult them from undertaking what must prove a fruitless task.

Above the olive-green shale and sandstone just mentioned, come red shales and sandstones of vast thickness. These form the red ground between Half-Falls mountain and Duncan's island, and outside the Cove along Sherman's Creek and Fishing Creek valleys. In this formation, *Catskill No. IX*, several thin seams of vegetable matter resembling coal have been seen, but nothing, so far as I know in Perry county, that has looked promising enough to tempt much investigation.

Over the Catskill formation No. IX, lies the Pocono formation No. X, the great sandstones of Cove, Buffalo, and Berry's mountains. Here the indications of coming coal are stronger. Seams of mineral fuel occur at various levels through their mass. In all these mountains serious attempts have been made at different times, *mostly, I believe, by persons not acquainted with the district, or with its geology*, to open coal mines. Opposite Newport, in the mountain gap, traces of such workings may be seen. At Mt. Patrick, too, a gangway has been driven for a long distance in a coal seam, from which a considerable quantity has been taken out.* The same is true of various places on the Cove mountain. But every one of these undertakings has been abandoned. The inference is—they were not profitable.

Over the great sandstone No. X lie the red shales of the two coves, in which no coal is found.

We have now gone through the whole series of Perry county rocks from the lowest to the highest, and only in one of them, the No. X sandstone, have we found any evidence of the presence of coal that deserves a moment's consideration. But outside of the county, in Dauphin county, the red shales dip under the great conglomerate which supports the genuine coal measures of Pennsylvania.

A little consideration of the facts above presented will show any thoughtful reader the nature of the evidence on

* See Page Plate VIII, Fig. 2.

which geologists deny the existence of workable coal in Perry county. The rocks are too old. They were made before the great coal-making age of the earth's history began. It seems as if the process of coal-making had been begun by Nature on a small scale, as if she were trying her "prentice han'" at the work. In her Cambro-Silurian days she succeeded in making the little thin layer in the Horse valley, and abandoned the attempt. In Devonian days she tried again, and obtained rather better success, forming the little "coals" above described of several inches in thickness. Again, she laid the task aside as beyond her strength, and not till the Lower Carboniferous (Pocono No. X) age did she take it in hand again. By this time the conditions of the earth had become more favorable, and Nature succeeded in producing such coal seams as that at Mt. Patrick and in the Buffalo and Cove mountains. These were fine achievements compared with her previous failures, but miserable failures compared with her subsequent triumphs. They are coal beds which have burnt the fingers of those who attempted to handle them; coal beds from which it costs a dollar to obtain fifty cents' worth of coal.

If it be asked why the coal near Duncannon (which is the same as that near Liverpool) is not workable, the answer is easy. In the first place, the beds are too thin. Beds of coal two feet thick will scarcely pay to work, even in the anthracite region, and I know no bed in Perry county even as thick as that. In the second place, it is often necessary to take out a great deal of rock, sometimes hard sandstone, in "getting" the coal. This is very expensive. In the third place, where the coal is obtained, though "burnable," yet it leaves between 30 and 40 per cent. of ash—one ton out of three. Good coal should not exceed 10 or 15 per cent., and the best coal has but 5 or less per cent of ash.

An examination of the sections will show that over New Bloomfield the coal measures, when they existed, lay at a height of about 22,000 feet above the present surface. Is it surprising, in view of these facts, that geologists speak of coal-seeking in Perry county as folly and infatuation?

Analyses of Pocono (Duncannon) coal are to be found in

Report M², page 100, made by Mr. A. S. McCreath, the Chemist of the Survey :

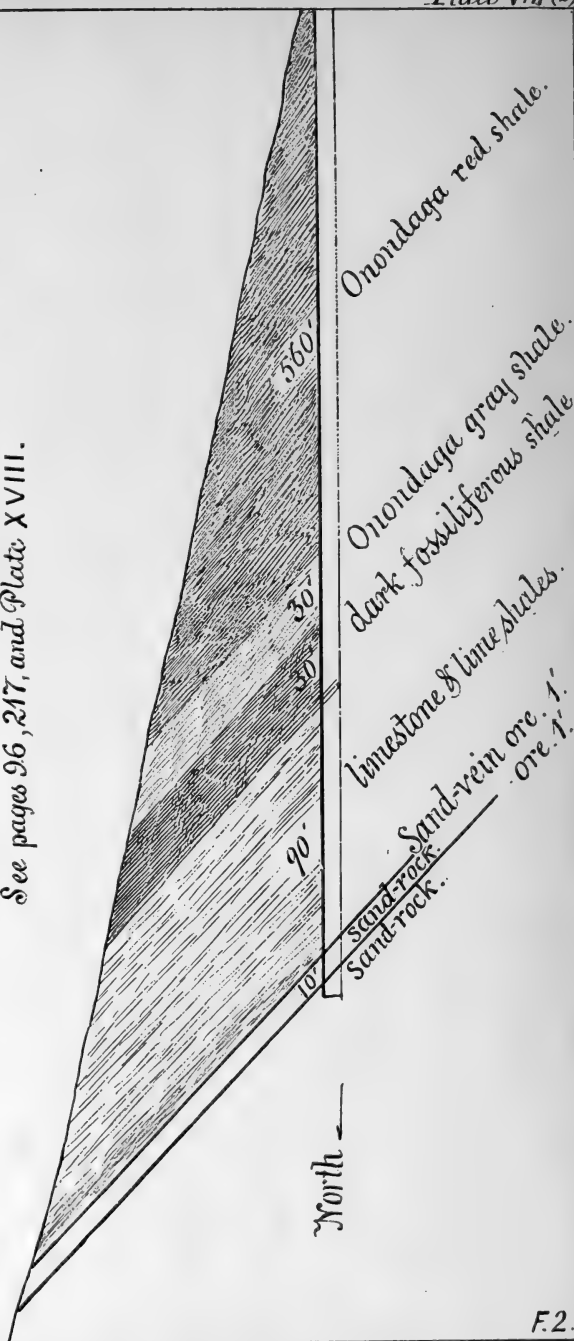
	(697a) <i>Cove</i> <i>Mountain.</i>	(697b) <i>Cove</i> <i>Mountain.</i>
Water at 225°, . . . . .	.570	.320
Volatile matter,	14.380	15.500
Fixed carbon,	48.285	50.709
Sulphur, . . . . .	.320	.206
Ash,	36.445	33.265
	<u>100.000</u>	<u>100.000</u>

697a was selected by Mr. William C. McFadden, and 697b by Mr. McCreath himself.

Section in Plauterbeck hill, Greenwood township.

Cut by Tunnel No. 9. R. Cochran, Esq.

See pages 96, 217, and Plate XVIII.



CHAPTER VI.

Catalogue of the Names of Plants found in Perry county during the summer of 1882 and 1883.

The plants named in the following list were collected or observed chiefly in the neighborhood of New Bloomfield, but not a few were obtained during the prosecution of geological work in the more distant parts of the county. It is by no means a complete catalogue of the Flora, time not having allowed much search for plants. It consequently contains only the names of the more obvious species. The absence, total or partial, of several genera will be noticed, such as the sedges, willows, &c. The aquatic plants too are scantily represented being less easily found.

Several common genera and species will also be missed, the Baneberries, (*Actæa*,) the Twinleaf, (*Jeffersonia diphylla*,) the Sundew, (*Drasera*,) and the Trilliums.

Names marked with an asterisk (*) are those of trees planted in the streets or similar places, but not showing any disposition to spread.

Names marked with a dagger (†) are those of plants growing in abandoned gardens or escaped from cultivation, but not yet naturalized, though showing a disposition to become so.

Ranunculaceæ:

Clematis Viorna, L.,	Leather-Flower.
" Virginiana, L.,	Common Virgin's-Bower.
Anemone Virginiana, L.,	Virginian Anemone.
" nemorosa, L.,	Wind-Flower, Wood Anemone.
Hepatica triloba, Chaix.,	Round-lobed Hepatica.
Thalictrum anemonoides, Michx.,	Rue-Anemone.
" dioicum, L.,	Early Meadow Rue.
" purpurascens, L.,	Purplish Meadow Rue.
" Cornuti, L.,	Tall Meadow Rue.
Ranunculus pusillus, Poir.,	Dwarf Crowfoot.
" abortivus, L.,	Small-Flowered Crowfoot.
" sceleratus, L.,	Cursed Crowfoot.
" recurvatus, Poir.,	Hooked Crowfoot.
" fascicularis, Muhl.,	Early Crowfoot.
Caltha palustris, L.,	Marsh Marigold.
+Helleborus viridis, L.,	Green Hellebore.
Aquilegia Canadensis, L.,	Wild Columbine.
Delphinium consolida, L.,	Field Larkspur.
Cimicifuga racemosa, Ell.,	Black Snakeroot, Bugbane.

Magnoliaceæ:

Magnolia acuminata, L.,	Cucumber-tree.
Liriodendron tulipiferum, L.,	Tulip-tree.

Anonaceæ :		
Asimina triloba, Dunal.,	Common Pawpaw.	
Menispermaceæ :		
Menispermum Canadense, L.,	Canadian Moonseed.	
Berberidaceæ :		
Caulophyllum thalictroides, Michx.,	Blue Cohosh, Pappoose-root.	
Podophyllum peltatum, L.,	May-apple, Mandrake.	
Nymphæaceæ :		
Nymphaea odorata, Ait.,	Sweet-scented Water-Lily.	
Nuphar advena, Ait.,	Common Yellow Pond-Lily.	
Papaveraceæ :		
Chelidonium majus, L.,	Great Celandine.	
Sanguinaria Canadensis, L.,	Blood-root.	
Fumariaceæ :		
Dicentra Cucullaria, D. C.,	Dutchman's Breeches.	
Corydalis flavula, Raf.,	Yellow Corydalis.	
Cruciferae :		
Nasturtium officinale, R. Br.,	True Water-cress.	
Nasturtium sylvestre, R. Br.,	Yellow Cress.	
Nasturtium palustre, D. C.,	Marsh Cress.	
Dentaria maxima, Nutt.,	Great Toothwort.	
“ laciniata, Muhl.,	Cut-leaved Toothwort.	
Cardamine rhomboidea, D. C.,	Spring Cress.	

Cardamine rotundifolia, Michx.,	Mountain Water-cress.
Cardamine, hirsuta, L.,	Small Bitter Cress.
Arabis lyrata, L.,	
“ patens, Sulliv.,	Spreading Rock-cress.
“ lævigata, D. C.,	Smooth Rock-cress.
“ Canadensis, L.,	Sickle-pod.
Erysimum cheiranthoides, L.,	Worm-seed Mustard.
Sisymbrium officinale, Scop.,	Hedge Mustard.
Sisymbrium thaliana, Gaud.,	Mouse-ear Cress.
Brassica nigra, Boiss.,	Black Mustard.
Draba verna, L.,	Whitlow-grass.
Camelina sativa, Crantz.,	False Flax.
Capsella Bursa-pastoris, Moench.,	Shepherd's Purse.
Lepidium Virginicum, L.,	Wild Pepper-grass.
Violaceæ:	
Viola lanceolata, L.,	Lance-leaved Violet.
“ blanda, Willd.,	Sweet White Violet.
“ cucullata, Ait.,	Common Blue Violet.
“	“ “ marked with white.
“	“
“ var. palmata,	Hand-leaved Violet.
“ var. cordata,	Heart-leaved Violet.
“ sagittata, Ait.,	Arrow-leaved Violet.
“ canina, L., var. sylvestris, Regel.,	Dog Violet.

"	striata, Ait.,	Pale Violet.
"	pubescens, Ait.,	Downy Yellow Violet.
"	tricolor, L.,	Pansy Heart's-ease.

Cistaceæ:

Lechea	thymifolia, Pursh.,	Thyme-leaved Pinweed.
"	minor, Lam.,	Small Pinweed.

Hypericaceæ:

Hypericum	prolificum, L.,	Shrubby St. John's-wort.
"	perforatum, L.,	Common St. John's-wort.
"	corymbosum, Muhl.,	Flat-topped St. John's-wort.
"	mutilum, L.,	Small flowered St. John's-wort.
"	Sarothra, Michx.,	Orange-grass, Pine-weed.
Elodes	Virginica, Nutt.,	Marsh St. John's-wort.

Caryophyllaceæ:

Saponaria	officinalis, L.,	Common Soapwort, Bouncing Bet.
Silene	stellata, Ait.,	Starry Campion.
"	nivea, D. C.,	White Campion.
"	Pennsylvanica, Michx.,	Wild Pink.
Synchis	Githago, Lam.,	Corn Cockle.
Stellaria	media, Smith,	Common Chickweed.
"	uliginosa, Murr.,	Swamp Starwort.
Cerastium	vulgatum, L.,	Mouse-ear Chickweed.
"	arvense, L.,	Field Chickweed.

Anychia dichotoma, Michx.,	Forked Chickweed.
Mollugo verticillata, L.,	Carpet-weed.
Portulacaceæ:	
Portulaca oleracea, L.,	Common Purslane.
Claytonia Virginica, L.,	Spring Beauty.
Malvaceæ:	
Malva rotundifolia, L.,	Common Mallow.
“ moschata, L.,	Musk Mallow.
Abutilon Avicennæ, Gaertn.,	Velvet-leaf.
Tiliaceæ:	
Tilia Americana, L.,	Bass-wood.
Linaceæ:	
Linum Virginianum, L.,	Small Flax.
Geraniaceæ:	
Geranium maculatum, L.,	Wild Cranesbill.
“ Carolinianum, L.,	Carolina Cranesbill.
“ pusillum, L.,	Small-flowered Cranesbill.
Impatiens fulva, Nutt.,	Spotted Touch-me-not Jewel-weed.
Oxalis, violacea, L.,	Violet Wood Sorrel.
“ stricta, L.,	Yellow Wood Sorrel.
Anacardiaceæ:	
Rhus typhina, L.,	Staghorn Sumach.
“ copallina, L.,	Dwarf Sumach.

<i>Rhus toxicodendron</i> , L.,	Poison Ivy.
" <i>aromatica</i> , Ait.,	Fragrant Sumach.
Vitaceæ:	
<i>Vitis labrusca</i> , L.,	Northern Fox-Grape.
" <i>aestivalis</i> , Michx.,	Summer Grape.
" <i>cordifolia</i> , Michx.,	Winter or Frost Grape.
<i>Ampelopsis quinquefolia</i> , Michx.,	Virginian Creeper.
Rhamnaceæ:	
<i>Ceanothus Americanus</i> , L.,	New Jersey Tea.
Celastraceæ:	
<i>Celastrus scandens</i> , L.,	Climbing Bitter-sweet.
<i>Euonymus atropurpureus</i> , Jacq.,	Wahoo.
Sapindaceæ:	
<i>Staphylea trifolia</i> , L.,	Bladder-nut.
<i>Acer Pennsylvanicum</i> , L.,	Striped Maple.
* <i>Aesculus glabra</i> , Willd.,	Buckeye.
" <i>spicatum</i> , Lam.,	Mountain Maple.
" <i>saccharinum</i> , Wang.,	Sugar Maple.
" <i>dasy carpum</i> , Ehrhart,	White Maple.
" <i>rubrum</i> , L.,	Red or Swamp Maple.
" * <i>platanoides</i> ,	Norway Maple.
* <i>Negundo aceroides</i> , Moench,	Box Elder.

Polygalacæ:

<i>Polygala sanguinea</i> , L.,	Red Milkwort.
“ <i>verticillata</i> , L.,	Whorled Milkwort.
“ <i>paucifolia</i> , Willd.,	Fringed Milkwort.

Leguminosæ:

<i>Lupinus perennis</i> , L.,	Wild Lupine.
<i>Crotalaria sagittalis</i> , L.,	Rattle-box.
<i>Trifolium arvense</i> , L.,	Rabbit-foot Clover.
“ <i>pratense</i> , L.,	Red Clover.
“ <i>repens</i> , L.,	White Clover.
“ <i>agrarium</i> , L.,	Yellow or Hop-Clover.
<i>Melilotus alba</i> , Lam.,	White Melilot.
<i>Robinia pseudacacia</i> , L.,	Black Locust.
<i>Tephrosia virginiana</i> , Pers.,	Hoary Pea.
<i>Desmodium nudiflorum</i> , D. C.,	Naked Tick-Trefoil.
“ <i>rigidum</i> , D. C.,	Stiff Tick-Trefoil.
<i>Lespedeza violacea</i> , var. <i>sessiliflora</i> , Pers.,	Purple Bush-Clover.
“ <i>Stuvei</i> , Nutt.,	Many-flowered Bush-Clover.
“ <i>hirta</i> , Ell.,	Hairy Bush-Clover.
<i>Vicia Caroliniana</i> , Walt.,	Carolina Vetch.
“ <i>Americana</i> , Muhl.,	American Vetch.
<i>Lathyrus, venosus</i> , Muhl.,	Veiny Vetchling.
“ <i>palustris</i> , L.,	Marsh Vetchling.

<i>Apios tuberosa</i> , Moench,	Ground-nut, Wild Bean.
<i>Amphicarpaea monoica</i> , Nutt.,	Hog Pea-nut.
<i>Galactia glabella</i> , Michx.,	Smooth Milk-Pea.
<i>Baptisia tinctoria</i> , R. Br.,	Wild Indigo.
<i>Cercis Canadensis</i> , L.,	Red-bud, Judas-tree.
<i>Cassia Marilandica</i> , L.,	Wild Senna.
“ <i>Chamaecrista</i> , L.,	Partridge Pea.
* <i>Gymnocladus Canadensis</i> , Lam.,	Kentucky Coffee-tree.
<i>Gleditschia triacanthos</i> , L.,	Honey-Locust.
Rosaceæ :	
<i>Prunus Americana</i> , Marshall,	Wild Red Plum.
“ <i>pumila</i> , L.,	Dwarf Cherry.
“ <i>Pennsylvanica</i> , L.,	Wild Red Cherry.
“ <i>serotina</i> , Ehrhart,	Wild Black Cherry.
<i>Spiræa opulifolia</i> , L.,	Nine-bark.
<i>Gillenlia trifoliata</i> , Mönch,	Bowman's Root.
<i>Agrimonia Eupatoria</i> , L.,	Common Agrimony.
<i>Geum album</i> , Gmelin,	White Avena.
<i>Waldsteinia fragarioides</i> , Tratt.,	Barren Strawberry.
<i>Potentilla Norvegica</i> , L.,	Large Three-leaved Cinque-foil.
“ <i>Canadensis</i> , L.,	Common Cinque foil.
<i>Fragaria Virginiana</i> , Ehrhart,	Wild Strawberry.
<i>Rubus odoratus</i> , L.,	Purple Flowering-Raspberry.

<i>Rubus occidentalis</i> , L.,	Black Raspberry, Thimbleberry.
" <i>villosus</i> , Ait.,	Common or High Blackberry.
" <i>Canadensis</i> , L.,	Low Blackberry, Dewberry.
<i>Rosa Carolina</i> , L.,	Swamp Rose.
" <i>rubiginosa</i> , L.,	Sweet-Brier.
<i>Crataegus coccinea</i> , L.,	Scarlet-fruited Thorn.
" <i>crusgalli</i> , L.,	Cockspur Thorn.
" <i>parvifolia</i> , Ait.,	Dwarf Thorn.
<i>Pyrus coronaria</i> , L.,	American Crab-Apple.
" <i>angustifolia</i> , Ait.,	Narrow-leaved Crab-Apple.
" <i>arbutifolia</i> , L.,	Choke-berry.
<i>Amelanchier Canadensis</i> , Torr. and Gray,	Shad-bush.
Saxifragaceæ:	
<i>Ribes hirtellum</i> , Michx.,	Smooth Gooseberry.
" <i>rotundifolium</i> , Michx.,	Round-leaved Gooseberry.
" <i>lacustre</i> , Poir.,	Bristly Gooseberry.
" <i>prostratum</i> , L'Her.,	Fetid Currant.
" <i>floridum</i> , L.,	Wild Black Currant.
<i>Hydrangea arborescens</i> , L.,	Wild Hydrangea.
<i>Saxifraga Virginicensis</i> , Michx.,	Early Saxifrage
" <i>Pennsylvanica</i> , L.,	Swamp Saxifrage.
<i>Heuchera Americana</i> , L.,	Common Alum-root.
<i>Mitella diphylla</i> , L.,	Two-leaved Mitrewort.

<i>Chrysosplenium Americanum</i> Schwein,	Golden Saxifrage.
Crassulaceæ:	
<i>Penthorum sedoides</i> , L.,	Ditch Stone-crop.
<i>Sedum ternatum</i> , Michx.,	Three-headed Orpine.
“ <i>Telephium</i> , L.,	Garden Orpine, Live-for-ever.
Hamamelaceæ:	
<i>Hamamelis Virginica</i> , L.,	Witch-Hazel.
Onagraceæ:	
<i>Circea Lutetiana</i> , L.,	Tall Enchanter's Night-shade.
“ <i>alpina</i> , L.,	Low Enchanter's Night-shade.
<i>Gaura biennis</i> , L.,	Sessile-flowered Gaura.
<i>Epilobium angustifolium</i> , L.,	Great Willow-herb.
“ <i>palustre</i> , L., var. <i>lineare</i> .,	Marsh Willow-herb.
<i>Epilobium coloratum</i> , Muhl.	
<i>Oenothera biennis</i> , L.,	Common Evening-Primrose.
“ <i>pumila</i> , L.,	Low Evening-Primrose.
<i>Ludwigia alternifolia</i> , L.,	Seed-box.
Lythraceæ:	
<i>Cuphea viscosissima</i> , Jacq.,	Clammy Cuphea.
Cucurbitaceæ:	
<i>Sicyos angulatus</i> , L.,	One-seeded Star-Cucumber.
Umbelliferae:	
<i>Hydrocotyle Americana</i> , L.,	Small Water Penny-wort.

<i>Sanicula Marilandica</i> , L.,	Stiff Sanicle.
<i>Daucus carota</i> , L.,	Common Carrot.
<i>Pastinaca sativa</i> , L.,	Common Parsnip.
<i>Angelica Curtisii</i> , Buckley,	Angelica.
<i>Archangelica hirsuta</i> , Torr. and Gr.,	Downy Archangelica.
“ <i>atropurpurea</i> , Hoffman,	Great Angelica.
<i>Thaspium aureum</i> , Nutt.,	Golden Meadow Parsnip.
“ <i>trifoliatum</i> ,	Three-leaved Meadow-Parsnip.
<i>Zizia integrifolia</i> , D. C.,	<i>Zizia</i> .
<i>Cicuta maculata</i> , L.,	Spotted Cowbane.
<i>Cryptotaenia</i> , <i>Canadensis</i> , D. C.,	Honewort.
<i>Chaerophyllum procumbens</i> , Lam.,	Spreading Chervil.
<i>Osmorrhiza longistylis</i> , D. C.,	Smooth Sweet Cicely.
“ <i>brevistylis</i> , D. C.,	Hairy Sweet Cicely.
Araliaceæ :	
<i>Aralia racemosa</i> , L.,	Spikenard.
“ <i>nudicaulis</i> , L.,	Wild Sarsaparilla.
Cornaceæ :	
<i>Cornus Canadensis</i> , L.,	Pigeon-berry, Dwarf Dogwood.
“ <i>florida</i> , L.,	Flowering Dogwood.
“ <i>stolonifera</i> , Michx.,	Red-osier Dogwood.
“ <i>paniculata</i> , L'Her.,	Panicled Dogwood.
“ <i>alternifolia</i> , L.,	Alternate-leaved Dogwood.

<i>Nyssa multiflora</i> , Wang.,	Black or Sour Gum.
Caprifoliaceæ:	
<i>Symphoricarpos racemosus</i> , Michx.,	Snowberry.
<i>Lonicera parviflora</i> , Lam.,	Small Honeysuckle.
“ <i>ciliata</i> , Muhl.,	Fly-Honeysuckle.
<i>Diervilla trifida</i> , Moench.,	Bush Honeysuckle.
<i>Sambucus Canadensis</i> , L.,	Common Elder.
“ <i>pubens</i> , Michx.,	Red-berried Elder.
<i>Viburnum prunifolium</i> , L.,	Black Haw.
“ <i>acerifolium</i> , L.,	Maple-leaved Viburnum.
Rubiaceæ:	
<i>Galium Aparine</i> , L.,	Cleavers' Goose-grass.
“ <i>trifidum</i> , L.,	Small Bedstraw.
“ <i>circæzans</i> , Michx.,	Wild Liqueurice.
“ <i>lanceolatum</i> , Torr.,	Lance-leaved Wild Liqueurice.
<i>Cephalanthus occidentalis</i> , L.,	Button-bush.
<i>Mitchella repens</i> , L.,	Partridge-berry.
<i>Houstonia purpurea</i> , L. var <i>longifolia</i> .,	Purple Houstonia.
“ <i>cærulea</i> , L.,	Sky-blue Houstonia, Bluets.
Valerianaceæ:	
<i>Fedia olitoria</i> , Vahl.,	Lamb-Lettuce.
Dipsacaceæ:	
<i>Dipsacus sylvestris</i> , Mill.,	Wild Teazel.

Compositæ:

Vernonia Novboracensis, Willd.,	Awned Ironweed.
Liatrix scariosa, Willd.,	Purple-tipped Blazing Star.
Eupatorium purpureum, L.,	Joe-Pye Weed, Trumpet Weed.
“ perfoliatum, L.,	Thoroughwort, Boneset.
“ ageratoides, L.,	White Snake-root.
Sericocarpus conyzoides, Nees.,	White-topped Aster.
Aster corymbosus, Ait.,	Corymbed Aster.
“ macrophyllus, L.,	Large-leaved Aster.
“ patens, Ait.,	Spreading Aster.
“ lævis, L. var lævigatus,	Smooth Aster.
“ azureus, Lindl.,	Azure Aster.
“ undulatus, L.,	Wavy-leaved Aster.
“ cordifolius, L.,	Heart-leaved Aster.
“ ericoides, L.,	Heath-leaved Aster.
“ dumosus, L.,	Bushy Aster.
“ Trades canti, L.,	Tradescant's Aster.
“ miser, L., Ait.,	Short-rayed Aster.
“ simplex, Willd.	
“ carneus, Nees.	
“ puniceus, L.	
“ prenanthoides, Muhl.	
“ oblongifolius, Nutt.,	Oblong-leaved Aster.

Aster Novæ-Angliæ, L.,	New England Aster.
Erigeron Canadensis, L.,	Horse-weed.
“ Philadelphicus, L.,	Common Fleabane.
“ annuus, Pers.,	Daisy Fleabane.
“ strigosus, Muhl.,	Perennial Daisy Fleabane.
Diplopappus umbellatus, Torr. & Gray,	Double-bristled Aster.
Solidago squarrosa, Muhl.,	Scaly Golden-rod.
“ bicolor, L.,	Hoary Golden-rod.
“ bicolor, L. var. concolor,	Hoary Yellow Golden-rod.
“ caesia, L.	
“ puberula, Nutt.	
“ speciosa, Nutt.,	Showy Golden-rod.
“ neglecta, Torr. & Gray.	
“ patula, Muhl.,	Rough-leaved Golden-rod.
“ arguta, Ait.	
“ Muhlenbergii, Torr. & Gray.	
“ altissima, L.,	Tall Golden-rod.
“ ulmifolia, Muhl.,	Elm-leaved Golden-rod.
“ odora, Ait.,	Sweet Golden-rod.
“ nemoralis, Ait.,	Early Golden-rod.
“ Canadensis, L.	
“ lanceolata, L.,	Lance-leaved Golden-rod.
Inula Helenium, L.,	Common Elecampane.

Ambrosia trifida, L.,	Great Ragweed.
“ artemisiifolia, L.,	Wormwood-leaved Ragweed.
Xanthium strumarium, L.,	Common Cocklebur.
Rudbeckia laciniata, L.,	Cut-leaved Cone Flower.
“ hirta, L.,	Bristly Cone Flower.
Helianthus microcephalus, Torr. & Gray,	Small-headed Sun-Flower.
Helianthus strumosus, L.,	
“ divaricatus, L.,	
“ hirsutus, Raf.,	Rough-leaved Sun-Flower.
“ decapetalus, L.,	Ten-petaled Sun-Flower.
Bidens frondosa, L.,	Common Beggar-ticks.
“ connata, Muhl.,	Swamp Beggar-ticks.
“ chrysanthemoides, Michx.,	Larger Bur-Marigold.
“ bipinnata, L.,	Spanish Needles.
Helenium autumnale, L.,	Sneeze-weed.
Maruta Cotula, D. C.,	Common May-weed.
Achillea millefolium, L.,	Common Yarrow.
Leucanthemum vulgare, Lam.,	Ox-eye Daisy.
Tanacetum vulgare, L.,	Common Tansy.
“ “ var. crispum,	Crisp Tansy.
Gnaphalium polycephalum, Michx.,	Common Everlasting.
Antennaria plantaginifolia, Hook,	Plantain-leaved Everlasting.
Erechtites hieracifolia, Raf.,	Fireweed.

<i>Cacalia atriplicifolia</i> , L.,	Pale Indian Plantain.
<i>Senecio aureus</i> , L.,	Squaw-weed.
<i>Cirsium lanceolatum</i> , Scop.,	Common Thistle.
“ <i>discolor</i> , Spreng.,	Tall Thistle.
“ <i>altissimum</i> , Spreng.,	Swamp Thistle.
“ <i>muticum</i> , Michx.,	Pasture Thistle.
“ <i>pumilum</i> , Spreng.,	Common Burdock.
<i>Lappa officinalis</i> , Allioni, var. <i>major</i> ,	Dwarf Dandelion.
<i>Krigia virginica</i> , Willd.,	Rough Hawkweed.
<i>Hieracium scabrum</i> , Michx.,	Rattlesnake-weed.
“ <i>venosum</i> , L.,	Panicled Hawkweed.
“ <i>paniculatum</i> , L.,	White Rattlesnake-root.
<i>Nabalus albus</i> , Hook.,	Tall White Rattlesnake-root.
“ <i>altissimus</i> , Hook.,	Common Dandelion.
<i>Taraxacum dens-leonis</i> , Desf.,	Wild Lettuce.
<i>Lactuca Canadensis</i> , L., var. <i>integrifolia</i> , Torr. & Gr.,	
Lobeliaceæ :	
<i>Lobelia cardinalis</i> , L.,	Cardinal-Flower.
“ <i>syphilitica</i> , L.,	Great Lobelia.
“ “ var. <i>alba</i> ,	Great White Lobelia.
“ <i>inflata</i> , L.,	Indian Tobacco.
“ <i>spicata</i> , Lam.,	Spiked Lobelia.

Campanulacæ:

Campanula aparinoides, Pursh.,	Marsh Bellflower.
“ Americana, L.,	Tall Bellflower.
Specularia perfoliata, A. D. C.,	Venus' Looking-Glass.

Ericacæ:

Gaylussacia brachycera, Michx.,	Box-Huckleberry.
“ frondosa, Torr. & Gray,	Blue Huckleberry.
“ resinosa, Torr. & Gray,	Black Huckleberry.
Vaccinium stamineum, L.,	Deerberry, Hogberry.
“ Pennsylvanicum, Lam.,	Dwarf Blueberry.
“ vacillans, Solander,	Low Blueberry.
“ corymbosum, L.,	Common or Swamp-Blueberry.
Epigæa repens, L.,	May-Flower.
Gaultheria procumbens, L.,	Creeping Wintergreen.
Andromeda ligustrina, Muhl.,	Andromeda.
Kalmia latifolia, L.,	Mountain Laurel.
Azalea nudiflora, L.,	Purple Azalia, Pinxter Flower.
Rhododendron maximum, L.,	Great Laurel.
Pyrola elliptica, Nutt.,	Shin-leaf.
“ chlorantha, Swartz,	Green-flowered Pyrola.
“ secunda, L.,	One-sided Pyrola.
Chimaphila umbellata, Nutt.,	Prince's Pine, Winter-green.
“ maculata, Pursh.,	Spotted Winter-green.

Monotropa uniflora, L.,	Indian-pipe, Corpse-plant.
“ Hypopitys, L.,	Pine-sap, False Beech-drops.
Aquifoliaceæ:	
Ilex verticillata, Gray,	Black Alder, Winterberry.
“ laevigata, Gray,	Smooth Winterberry.
Ebenaceæ:	
Diospyros Virginiana, L.,	Common Persimmon.
Plantaginaceæ:	
Plantago major,	Common Plantain.
“ lanceolata, L.,	Ribgrass, English Plantain
“ Virginica, L.,	Hoary Plantain.
Primulaceæ:	
Dodocatheon Meadia, L.,	Shooting Star.
Trientalis Americana, Pursh.,	Star-flower.
Lysimachia stricta, Ait.,	Rigid Loosestrife.
“ quadrifolia, L.,	Four-leaved Loosestrife.
“ ciliata,	Fringed Loosestrife.
Anagallis arvensis, L.,	Common Pimpernel.
Orobanchaceæ:	
Conopholis Americana, Walloth,	Squaw-root, Cancer-root.
Scrophulariaceæ:	
Verbascum thapsus, L.,	Common Mullein.
“ blattaria, L.,	Moth Mullein.

<i>Linaria vulgaris</i> , Mill.,	Toad-flax, Butter and eggs.
<i>Scrophularia nodosa</i> , L.,	Figwort.
<i>Chelone glabra</i> , L.,	Turtle-head.
<i>Pentstemon pubescens</i> , Solander,	Beard-tongue.
<i>Mimulus ringens</i> , L.,	Square-stemmed Monkey-flower.
“ <i>alatus</i> , Ait.,	Winged Monkey-flower.
<i>Hysanthes gratioides</i> , Benth.,	False Pimpernel.
<i>Veronica Americana</i> , Schweinitz,	American Brooklime.
“ <i>officinalis</i> , L.,	Common Speedwell.
“ <i>serpyllifolia</i> , L.,	Thyme-leaved Speedwell.
<i>Gerardia tenuifolia</i> , Vahl.,	Slender Gerardia.
“ <i>flava</i> , L., partly,	Downy False Foxglove.
“ <i>quercifolia</i> , Prush,	Smooth False Foxglove.
“ <i>pedicularia</i> , L.,	Cut-leaved Gerardia.
<i>Pedicularis Canadensis</i> , L.,	Common Lousewort.
<i>Melampyrum Americanum</i> , Michx.,	Cow-wheat.
Acanthaceæ :	
<i>Dianthera Americana</i> , L.,	Water-Willow.
Verbenaceæ :	
<i>Verbena hastata</i> , L.,	Blue Vervain.
“ <i>urticifolia</i> , L.,	White Vervain.
Labiatæ :	
<i>Teucrium Canadense</i> , L.,	American Germander.

Trichostema dichotomum, L.,	Blue-curls.
Mentha viridis, L.,	Spearmint.
“ piperita, L.,	Peppermint.
“ sativa, L.,	Whorled Mint.
Lycopus Europæus, L.,	Water Horehound.
Cunila Mariana, L.,	Common Dittany.
Pycnanthemum incanum, Michx.,	Hoary Mountain-mint.
Pycnanthemum lanceolatum, Pursh.,	Lance-leaved Mountain-mint.
Calamintha clinopodium, Benth.,	Basil.
Melissa officinalis, L.,	Common Balm.
Hedeoma pulegioides, Pers.,	American Pennyroyal.
Collinsonia Canadensis, L.,	Horse-balm.
Blephilia ciliata, Raf.,	Hairy Blephilia.
Nepeta Cataria, L.,	Catnip.
“ Glechoma, Benth.,	Ground Ivy.
Brunella vulgaris, L.,	Common Self-heal.
Scutellaria canescens, Nutt.,	Downy Skullcap.
“ pilosa, Michx.,	Hairy Skullcap.
“ integrifolia, L.,	Hoary Skullcap.
“ lateriflora, L.,	Mad-dog Skullcap.
Marrubium vulgare, L.,	Common Horehound.
Galeopsis Tetrahit, L.,	Common Hemp-Nettle.
Stachys palustris, L., var. aspera,	Rough Hedge-Nettle.

Leonurus cardiaca, L.,	Common Motherwort.
Borraginacæ:	
Echium vulgare, L.,	Blue-weed.
Symphytum officinale, L.,	Common Comfrey.
Lithospermum officinale, L.,	Common Gromwell.
“ canescens, Lehm.,	Hoary Puccoon.
Myosotispalustris, Withering var laxa,	Small True Forgetmenot.
Cynoglossum officinale, L.,	Common Hound's-tongue.
“ Virginicum, L.,	Wild Comfrey.
“ Morisoni, D. C.,	Beggar's Lice.
Hydrophyllacæ:	
Hydrophyllum Virginicum, L.,	Virginian Water-leaf.
Ellisia Nyctelea, L.,	Ellisia.
Phacelia parviflora, Pursh.,	Small-flowered Phacelia.
Polemoniaceæ:	
Polemonium reptans, L.,	Low Jacob's Ladder.
Phlox divaricata, L.,	Spreading Phlox.
Convolvulacæ:	
Calystegia sepium, R. Br.,	Hedge Bindweed.
Cuscuta Gronovii, Willd.,	Common Dodder.
Solanacæ:	
Solanum nigrum, L.,	Common Nightshade.
Physalis viscosa, L.,	Clammy Ground Cherry.

<i>Lycium vulgare</i> , Dunal.,	Matrimony-vine.
<i>Datura stramonium</i> , L.,	Common Thorn-apple.
Gentianaceæ:	
<i>Sabbatia angularis</i> , Pursh.,	Angled American Centaury.
<i>Gentiana Andrewsii</i> , Griseb.,	Closed Gentian.
<i>Obolaria Virginica</i> , L.,	Obolaria.
Apocynaceæ:	
<i>Apocynum androsæmifolium</i> , L.,	Spreading Dogbane.
Asclepiadaceæ:	
<i>Asclepias cornuti</i> , Decaisne,	Common Milkweed.
" <i>quadrifolia</i> , Jacq.,	Four-leaved Milkweed.
" <i>incarnata</i> , L.,	Swamp Milkweed.
" <i>obtusifolia</i> , Michx.,	Wavy-leaved Milkweed.
" <i>tuberosa</i> , L.,	Orange Milkweed.
Oleaceæ:	
+ <i>Syringa vulgaris</i> ,	Common Lilac.
<i>Fraxinus Americana</i> , L.,	White Ash.
" <i>sambucifolia</i> , Lam.,	Black or Water-Ash.
Aristolochiaceæ:	
<i>Asarum Canadense</i> , L.,	Wild Ginger.
Phytolaccaceæ:	
<i>Phytolacca decandra</i> , L.,	Common Pokeweed.

Chenopodiaceæ:

Chenopodium album, L.,	Lamb's Quarters, Pigweed.
“ urticum, L.,	Triangular-leaved Pigweed.

Amarantaceæ:

Amarantus retroflexus, L.,	Green Amaranth, Red-root.
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Polygonaceæ:

+Polygonum orientale, L.,	Prince's Feather.
“ incarnatum, Ell.,	Flesh-colored Polygonum.
“ persicaria, L.,	Lady's-thumb.
“ hydropiper, L.,	Common Smartweed or Water-pepper.
“ acre, H. B. K.,	Water Smartweed.
“ Virginianum, L.,	Virginian Water-pepper.
“ aviculare, L.,	Knotgrass, Goosegrass, Door-weed.
“ sagittatum, L.,	Arrow-leaved Tear-thumb.
“ dumetorum, L.,	Climbing False Buckwheat.
Rumex crispus, L.,	Curled Dock.
“ obtusifolius, L.,	Bitter Dock.
“ acetosella, L.,	Field or Sheep Sorrel.

Lauraceæ:

Sassafras officinale, Nees.,	Sassafras.
Lindera Benzoin, Meisner,	Spice-bush.

Santalaceæ:

Comandra umbellata, Nutt.,	Bastard Toad-Flax.
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Saururaceæ:

Saururus cernuus, L., Lizard's-tail.

Callitrichaceæ:

Callitriche heterophylla, Pursh, Water Starwort.

Euphorbiaceæ:

Euphorbia maculata, L., Spotted Spurge.
 " *hypericifolia*, L., St. John's wort Spurge.
 " *corollata*, L., Showy Spurge.
 " *dentata*, Michx., Toothed-leaved Spurge.

Urticaceæ:

Urtica fulva, Mich., Slippery or Red Elm.
 " *Americana*, L., American or White Elm.
 " *racemosa*, Thomas, Corky White Elm.
Celtis occidentalis, L., Hackberry.
Morus rubra, L., Red Mulberry.
 " *alba*, L., White Mulberry.
Urtica gracilis, Ait., Slender Nettle.
Laportea Canadensis, Gaudichand, Wood Nettle.
Pilea pumila, Gray, Richweed, Clearweed.
Parietaria Pennsylvanica, Muhl., Pellitory.
Cannabis sativa, L., Hemp.
Humulus lupulus, L., Common Hop.

Carpinus Americana, Michx.,	American Hornbeam.
Myricaceæ:	
Comptonia asplenifolia, Ait.,	Sweet Fern.
Betulaceæ:	
Betula lenta, L.,	Sweet or Black Birch.
“ alba, var populifolia, Spach.,	American White Birch.
“ nigra, L.,	River or Red Birch.
Alnus incana, Willd.,	Speckled or Hoary Alder.
Salicaceæ:	
Salix tristis, Ait.,	Dwarf Gray Willow.
“ alba, L.,	White Willow.
Populus tremuloides, Michx.,	American Aspen.
“ monilifera, Ait.,	Cotton-wood.
Coniferæ:	
Pinus rigida, Miller,	Pitch Pine.
“ strobus, L.,	White Pine.
“ inops,	Scrub Pine.
Abies nigra, Poir.,	Black or Double Spruce.
“ Canadensis, Michx.,	Hemlock Spruce.
*Thuja occidentalis, L.,	American Arbor Vitæ.
Juniperus Virginiana, L.,	Red Cedar.
Araceæ:	
Arisaema triphyllum, Torr.,	Indian Turnip.

<i>Arisaema dracontium</i> , Schott,	Dragon-root.
<i>Symplocarpus foetidus</i> , Salisb.,	Skunk Cabbage.
<i>Orontium aquaticum</i> , L.,	Golden-club.
Lemnaceæ:	
<i>Lemna minor</i> , L.,	Small Duckweed.
Alismaceæ:	
<i>Alisma plantago</i> , L. var <i>Americanum</i> ,	Water Plantain.
<i>Sagittaria variabilis</i> , Engelm.,	Arrow-head.
Orchidaceæ:	
<i>Habenaria ciliaris</i> , R. Br.,	Yellow Fringed-Orchis.
“ <i>psychodes</i> , Gray,	Purple Fringed-Orchis.
<i>Goodyera pubescens</i> , R. Br.,	Rattlesnake-Plantain.
<i>Spiranthes cernua</i> , Richard,	Nodding Ladies' Tresses.
“ <i>graminea</i> , Lindl. var <i>Walteri</i> ,	Grass-leaved Ladies' Tresses.
“ <i>gracilis</i> , Bigelow,	Slender Ladies' Tresses.
<i>Pagonia verticillata</i> , Nutt.,	Whorled Pagonia.
<i>Liparis liliifolia</i> , Richard,	Twayblade.
<i>Cypripedium parviflorum</i> , Salisb.,	Smaller Yellow-Lady's Slipper.
“ <i>acaule</i> , Ait.,	Purple Lady's Slipper.
Iridaceæ:	
<i>Iris versicolor</i> , L.,	Larger Blue Flag.
+ “ <i>verna</i> , L.,	Dwarf Iris.
<i>Sisyrinchium Bermudianum</i> ,	Blue-eyed Grass.

Amaryllidaceæ:	
Narcissus pseudonarcissus,	Daffodil.
Dioscoreaceæ:	
Dioscorea villosa, L.,	Wild Yam-root.
Smilacæ:	
Smilax rotundifolia, L.,	Common Greenbrier.
“ glauca, Walt.,	Smooth Greenbrier.
“ herbacea, L.,	Carrión Flower.
Liliaceæ:	
Medeola Virginica, L.,	Indian Cucumber-root.
Veratrum viride, Ait.,	American White Hellebore.
Chamaelirium luteum,	Devil's Bit.
Uvularia perfoliata, L.,	Perfoliate Bellwort.
“ sessilifolia, L.,	Sessile-leaved Bellwort.
Smilacina racemosa, Desf.,	False Spikenard.
“ bifolia, Ker.,	Two-leaved False Solomon's Seal.
Polygonatum biflorum, Ell.,	Smaller Solomon's Seal.
“ giganteum, Dietrich.,	Great Solomon's Seal.
†Asparagus officinalis, L.,	Garden Asparagus.
Lilium Philadelphicum, L.,	Wild Orange-Red Lily.
“ Canadense, L.,	Wild Yellow Lily.
Erythronium Americanum, Smith,	Dog's Tooth Violet.
Ornithogalum umbellatum, L.,	Star-of-Bethlehem.

Scilla Fraseri,	Wild Hyacinth.
Allium cernuum, Roth.,	Wild Onion.
“ Schoenoprasum, L.,	Chives.
“ vineale, L.,	Field Garlic.
+ Muscari botryoides, Mill.,	Grape Hyacinth.
+ Hemerocallis fulva, L.,	Common Day-Lily.
Juncaceæ:	
Luzula campestris, DC.,	Wood-Rush.
Commelynaceæ:	
Tradescantia Virginica, L.,	Common Spider-wort.
Xyridaceæ:	
Xyris flexuosa, Muhl., Chapm.,	Yellow-eyed Grass.
Cyperaceæ:	
Scirpus validus, Vahl.,	Great Bulrush.
Gramineæ:	
Leersia Virginica,	White Grass.
Phleum pratense, L.,	Timothy.
Agrotis vulgaris, With.,	Red-Top.
“ alba, L.,	White Bent Grass.
Cynodon dactylon, Pers.,	Scutch-Grass.
Dactylis glomerata, L.,	Orchard Grass.
Poa annua, L.,	Low Spear-Grass.
“ compressa, L.,	Wire-Grass.

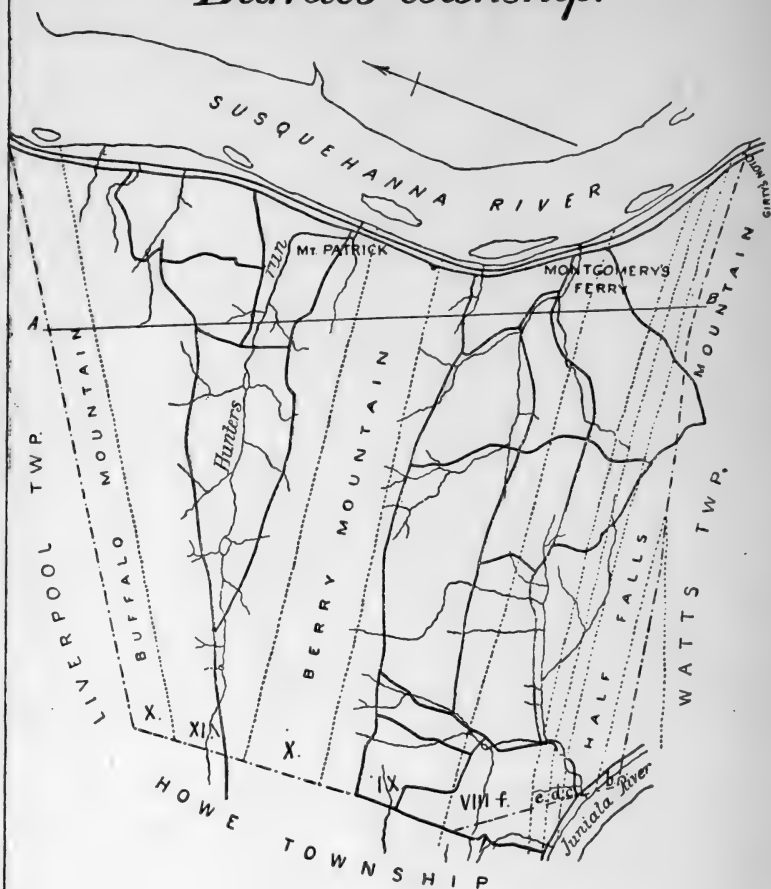
<i>Poa pratensis</i> , L.,	Kentucky Blue-Grass.
<i>Festuca elatior</i> , L.,	Meadow Fescue.
<i>Bromus secalinus</i> , L.,	Cheat or Chess.
<i>Lolium perenne</i> , L.,	Rye-Grass.
<i>Arrhenatherum avenaceum</i> , Beauv.,	Oat-Grass.
<i>Holcus lanatus</i> , L.,	Meadow Soft-Grass.
<i>Anthoxanthum odoratum</i> , L.,	Sweet Vernal-Grass.
<i>Phalaris arundinacea</i> , L.,	Reed Canary-Grass.
<i>Panicum sanguinale</i> , L.,	Five Finger-Grass.
“ <i>capillare</i> , L.,	Old-Witch-Grass.
“ <i>latifolium</i> , L.,	Broad-leaved Panic-Grass.
“ <i>depauperatum</i> , Muhl.,	Few-Flowered Panic-Grass.
“ <i>Crus-Galli</i> , L.,	Barnyard-Grass.
<i>Andropogon Virginicus</i> , L.,	Beard-Grass.
Equisetaceæ:	
<i>Equisetum arvense</i> , L.,	Common Horsetail.
“ <i>hyemale</i> , L.,	Scouring-Rush.
Filices:	
<i>Polypodium vulgare</i> , L.,	Common Polypody.
<i>Adiantum pedatum</i> , L.,	Bird's-Foot, Maiden-Hair.
<i>Pteris aquilina</i> , L.,	Common Brake.
<i>Asplenium Trichomanes</i> , L.,	Small Spleenwort.
“ <i>ebeneum</i> , Ait.,	Ebony Spleenwort.

<i>Camptosorus rhizophyllus</i> , Link,	Walking-Leaf.
<i>Phegopteris hexagonoptera</i> , Fée,	Beech-Fern.
<i>Aspidium Thelypteris</i> , Swartz,	Marsh Shield-Fern.
“ <i>Noveboracense</i> , Swartz,	Tapering Shield-Fern.
“ <i>spinulosum</i> , Swartz,	Prickly Shield-Fern.
“ <i>marginale</i> , Swartz,	Evergreen Shield-Fern.
“ <i>acrostichoides</i> , Swartz,	Stalked Shield-Fern.
<i>Cystopteris fragilis</i> , Bernh.,	Fragile Bladder-Fern.
<i>Struthiopteris Germanica</i> , Willd.,	Ostrich-Fern.
<i>Onoclea sensibilis</i> , L.,	Sensitive-Fern.
<i>Dicksonia punctilobula</i> , Kunze.,	Dicksonia.
<i>Osmunda regalis</i> , L.,	Flowering Fern.
“ <i>Claytoniana</i> , L.,	Interrupted Fern.
“ <i>cinnamomea</i> , L.,	Cinnamon-Fern.
<i>Botrychium Virginicum</i> , Swartz,	Rattlesnake-Fern.
“ <i>lunarioides</i> , Swartz,	Common Moonwort.
Lycopodiaceæ:	
<i>Lycopodium dendroideum</i> , Michx.,	Ground-Pine.
“ <i>clavatum</i> , L.,	Common Club-Moss.
<i>Marchantia polymorpha</i> ,	Liver-wort.

In the above list there is one species almost peculiar, being known, so far as I am aware, at only one other locality. The Box Huckleberry, *Gaylussaccia trachycera*, grows abundantly in a small tract of about ten acres near New Bloomfield. To this space it is, I believe, limited. Outside the county it is found on the banks of Indian river, near Millsborough, Sussex county, Delaware, as reported by Mr. A. Commons. It was described many years ago by Michaux, from Virginia, (Winchester and Warm springs,) but has been found there by no one since.

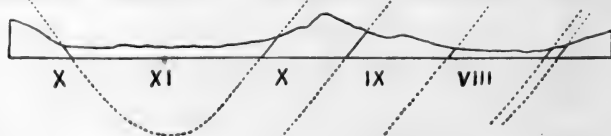
It appears to be a lingering relic of the ancient flora of the county, maintaining itself on the sterile hill-side of Chemung shale, but liable to be destroyed by cultivation at any time. It is exceedingly plentiful, forming a perfect mat over much of the ground, but its limits are sharply defined without apparent cause.

Buffalo township.



Section across Buffalo township along the line A.B.

Buffalo mtn. North Cove Berry mtn. Bucks Valley Half Falls mtn.



CHAPTER VII.

Geological description of the Townships in alphabetical order.

1. Buffalo township.

This township lies immediately south of Liverpool, and like it borders on the Susquehanna river, on which it has a water frontage of about 6 miles. Its northern boundary is the crest of Berry mountain from the river south-westward. Howe township borders it on the west. Its southern limit is the ridge of Half Falls mountain, which is the extension, across the Juniata, of Limestone ridge, Buffalo hills, Mahanoy ridge, and the arch of Dick's hill. It averages about 5 miles in length and breadth, and its area is not far from 25 square miles. It contains the two hamlets of Mt. Patrick and Montgomery ferry, both situated on the river.

Half Falls mountain forms the southern water-shed of the township. A broad valley is included between it and Berry's mountain, which is traversed nearly in the middle by what is known as the Middle Bucks Valley ridge. This ridge, however, forms no barrier to the streams, and consequently no water-shed. As is usually the case on Chemung outcrops, it is rather a succession of isolated hills than a range, for the streams that have their origin to the north of it pass through it at numerous points and unite to form two small rivers, or rather brooks, which fall into the Juniata. The eastern part of this vale is drained by another small stream which enters the Susquehanna at Montgomery.

The northern portion of the township presents the most interesting topographical features. Buffalo, taken together with Howe, presents a magnified picture of Penn township,

and a description of either of these might be taken with small error and applied to the other. As in Penn, so here. The northern part of Buffalo presents us with a district isolated from the rest of the county. Buffalo mountain on the north, and Berry's mountain on the south, are exact counterparts of Peters and Cove mountains. They fence in the district lying between them so completely and are so rugged and impracticable that not a single road crosses them in the township. The only ways of access to the intervening vale are from the west through Howe township and through the gaps of the Susquehanna river on the east. Most of the waters flowing down the slopes of this valley unite to form Hunter's run, a little river rising in Howe township and entering Buffalo on the west. It flows down the whole length of the vale and reaches the Susquehanna at Mt. Patrick.

Geological structure.

As the characteristic feature of Penn township is the extension of the southern point of the Pottsville coal basin across the Susquehanna, so the leading feature of Buffalo and Howe townships is the westward extension and termination of the northern point of the same basin. The Pocono sandstone, of which Buffalo mountain and Berry's mountain are composed, is one of the beds of the lower carboniferous system, and crops out all around the edge of the coal measures. It forms the lower limit of profitable coal seams. The Mauch Chunk red shale, which overlies it, is the material of which the isolated valley spoken of in the topographical account of the township is composed. This immediately overlies the sandstone. These two are the highest rocks in the geological series which occur in Perry county. Consequently, it is evident that no hope can be indulged of finding coal, unless it be in these three townships,* and even here geologists can give no ground for expecting any profitable coal bed.

*The geological argument on this question will be found more fully developed in the report on Penn township and in the chapter on the coals of Perry county. It is unnecessary to reproduce it here.

Thin seams of coal may be found, and have been cut in this part of the county, as at Mt. Patrick, but they have never been more than a few inches in thickness, and it would be mere waste of time and money to seek profitable coal seams either in Buffalo or Penn townships. See Chapter V, page 107, on the Perry county coals.

The Lower Helderberg limestone.

This, the great limestone of Perry county, makes but a feeble show in Buffalo township. The extreme point of Limestone ridge crosses the Juniata, forming a ridge of rocks in the stream, over which the water ripples, and which, probably, gave rise to the name Half Falls mountain. Rising in the face of the mountain, on the east bank, the limestone has been largely quarried to supply the district. The exposure is small, extending only a few hundred yards into the township, when it is overlapped by the Oriskany sandstone and Marcellus and Lower Hamilton rocks. The beds are much contorted, showing considerable disturbance. The fossiliferous beds are not exposed, but the rock consists of shaly thin-bedded limestones, with more solid beds near the bottom of the quarry. About thirty feet of "face" can be seen, but much of it is concealed behind the waste. This is the only exposure of the Lower Helderberg limestone in the county east of the Juniata, and south of Wild Cat ridge, and is the center of supply for the three townships of Howe, Buffalo, and Watts.

The chert beds, near the top of the group, are well exposed at Half Falls mountain, near the river. This is one of the few places in the county where these beds can be seen in place. They are about three feet thick so far as visible, but a greater thickness may be concealed.

The highest layers of the limestone in this place are exceedingly sandy, showing a manifest transition to the Oriskany. Some of the beds that have been quarried and burnt contain a very large proportion of sand, which is said not to interfere with the slacking, but of course diminishes the value of the product for agricultural purposes. The sandy limestone beds lie apparently below the chert beds, but the

strata are here so disturbed, that a slight dislocation may exist. Evidently there are here beds indicating a gradual transition from the Lower Helderberg limestone to the Oriskany sandstone. Similar beds may be found in the west of Tuscarora township.

The Oriskany sandstone.

No good exposure of this sandstone occurs in the township, but its presence is plainly indicated in places all round the outcrop of the limestone. It is coarse in texture, being a conglomerate of fine white quartz pebbles as at many other places in the county. A reef of this rock here crosses the river and helps to form the rapid.

The Marcellus and Hamilton lower shale.

An outcrop of the Marcellus black shale is said, in the report of the first survey, to exist at Half Falls mountain. I have seen no natural exposures of it, but it has been dug into in the woods near the lime quarry.

The Hamilton sandstone and upper shale.

Along the southern line of the township the Hamilton sandstone makes a long line of outcrop in Half Falls mountain, a high bold wooded ridge extending from the Juniata to the Susquehanna and forming a continuation, geologically speaking, of Buffalo hills, Limestone ridge, Mahanoy ridge, and Dick's hill, the latter thrown up by the Perry county fault. All these four ranges converge and meet at different points along the line of this township between the rivers, and finally die out at the Susquehanna. The influence of their hard sandstones may, however, be seen in the bend of the river to the eastward, about Girty's notch, where they project into its channel. This eastward or southeastward course is continued until the river strikes the Catskill and Pocono sandstone of Peters mountain, when it turns again to the southwest, and at length finds, or rather has made for itself a passage at Duncannon.

Near the east end of Half Falls mountain is the place so well known, locally, as Girty's notch, the home, or rather

abode, of Simon Girty, an outlaw who figured largely in the early history of this part of the State about the middle of the last century. The cave is still shown in which Simon is said to have dwelt, and an hotel now bears his name. According to the common account, Girty was banished from society for his vices, and lived mostly with the Indians. The situation of the place gave great facility for commanding the navigation of the river, because at low water the only passage-way for boats lies under the end of the mountain, the ledges of rock forming a rapid across most of the channel.

A quarry has recently been opened at the notch on land belonging to the Messrs. McCormick in the upper beds of the Hamilton sandstone, and a great quantity of stone taken out for the building of the new railroad bridge at Shamokin. The quarry is well situated and capable of yielding an inexhaustible supply of stone. The uppermost layers are soft but are easily removed, and then several beds of solid sandstone, some of them slightly conglomeratic, are met with. They vary from one to three feet in thickness, and dip at a very slight angle, about 10° , to the south. An inclined plane with railway runs from the quarry to the canal side, where a derrick has been erected for loading the stone. Another quarry has been open for some years about a mile from this one, for an account of which see the report on Watts township.

No outcrop of the upper shale has been seen in this township, but it must certainly exist, as it is found just over the line in Watts township, and there abounds in its characteristic fossils.

The Chemung group.

The olive gray shales and sandstones of this group cross the township from east to west, and are fairly well exhibited at the Juniata river section. The harder upper beds constitute Middle Bucks Valley ridge, which is really only a continuation of Middle ridge in Centre and Oliver townships, the two parts being sundered by the Juniata. The river has in fact made three gaps across the line of outcrop

of these shales, cutting it into four parts, one of which is in Juniata or Oliver townships, another in Howe, a third in Miller, and a fourth in Buffalo.

The rocks here present the same rounded surface and comparatively poor soil that characterize their outcrop in other parts of the county.

The Catskill group.

The red rocks of this group crop out in a line across the township from the Susquehanna to the Juniata. But they present no feature calling for special mention. They lie between the south slope of Berry mountain and Middle Bucks Valley ridge.

The Pocono sandstone.

The southern outcrop of the Pocono sandstone in Berry mountain divides Buffalo township into two parts, one of which consists of what we may call the Northern cove of Perry county, and the other of the wide and ridgy Bucks valley. Each division includes its bounding mountain walls. An account of this southern outcrop of the sandstone will be sufficient, as the northern outcrop shows no difference. The Pocono sandstone is here about 2000 feet thick, and its solid, hard beds rise at an angle of about 65° to the south, dipping northward under the red shale of the cove to rise again in Buffalo mountain three miles or less further north. This is the same sandstone as that of the Southern cove, and like it underlies the true coal measures, but at a distance below them of nearly 2000 feet. It very closely resembles the sandstone immediately underlying these measures, and has often been mistaken for it by miners unacquainted with geology. It also contains at least one seam of coal and probably more; sufficient to entice such men into spending money and labor, but not sufficient to reward them. The coal beds in the Pocono sandstone are a mere will-o'-the-wisp, luring on the miners yard after yard into the solid hills, and finally disappearing when just within their grasp.

Many a chapter might be written on the disappointment

and loss incurred by men who either through ignorance or through obstinacy persist in thus exploring "the bowels of the earth" for treasures that do not exist. None are so groundlessly hopeful as those who are in quest of "mineral," be it coal or ore. The treasure is always a few yards beyond them. The seam or vein is always going to thicken. The quality will improve as they go farther or deeper. Men who in all other respects are rational seem to lose their reason when they set out on the search for ore. Few of them will take advice. They *know* there is something in the hill. If not, "What is it good for?" say they. There *is something* in every hill. Millions of tons of sandstone or shale or limestone, but not necessarily ore or coal. From a miner's point of view many hills and mountains, many whole ranges, are good for nothing. In spite of his confident assertion, the geologist can often tell him before he begins to dig that he will find nothing to repay his labor. But he will seldom listen. He goes on and adds another to the already long list of foolish undertakings and failures that may be found in the history of almost every county and township in Pennsylvania. Had the money thus sunk been wisely expended we might now possess a good topographical and geological map of the whole State. Money enough has been spent in several townships in Perry county to pay for complete surveys.

The Coals of Buffalo township.

Some years ago a drift was run into the end of Berry mountain, in the face of the gap, by some persons from Baltimore in the hope of finding coal. The drift was carried about 300 feet into the hill and at its farther end the coal seam *is said to be* three feet thick. Two openings were made, one a little higher and a little farther north than the other. How far the northern level was carried I could not learn. Some of the sandstone forming the roof has fallen and more is loose. Entrance is therefore hazardous.

A section at the mouth of the tunnel reads as follows (See Page Plate VIII, page 92, Fig. 2):

i. Sandstone,	—
h. Thin yellow sandstone, (8 inches,)	0' 8"
g. Coal, (1 inch,)	1"
f. Thin, smooth, soft, green shale, (6 inches,)	6"
e. Slaty coal, soft, (1 inch,)	1"
d. Red, rubbly shale,	—
c. Green, rubbly shale,	—
b. Thin coal seam, (1 inch,)	1"
a. Green, smooth, sandy shale with yellow ochre and plants.	

No coal of marketable quality was obtained from this opening. It is soft, and has white shale seams or flakes in it. I was informed that it was equally soft at the end of the level.

On the left side, at the entrance, is a bed full of plant remains, but they are injured by compression and slaty cleavage. After working for more than two hours, I failed to get a single piece that I could recognize with certainty. There was little to be obtained, except the long-wrinkled or ribbed grass-like impressions, probably the leaves of a large *Calamites*. In the wall of the tunnel is an impression of a Calamite, about three feet long and six inches in thickness or rather breadth, and another of smaller size is below it. A third I extricated in part from the sandstone wall of the northern opening. These were probably the stems from which the enormous quantity of leaves that are found in the same beds have fallen. They resemble *Calamites transitionis*, (Goep.,) but are not in condition for identification. Strongly-ribbed (with only one rib in the middle) casts are common here, which may be small stems or even leaves.

In the bed marked *h* is a heavy black ferruginous conglomerate, with pebbles (concretions?) of red and yellow ochre, and others of a hard sandy clay stone. It is a lean iron ore, but of no value.

There is no evidence of the growth of these plants on the spot where their remains occur. No traces of roots of any kind appeared. From their position in the shale, from their broken and comminuted condition, it seems certain that they were drifted to the spot and buried. The growth must have been monotonous, consisting almost wholly of one species.

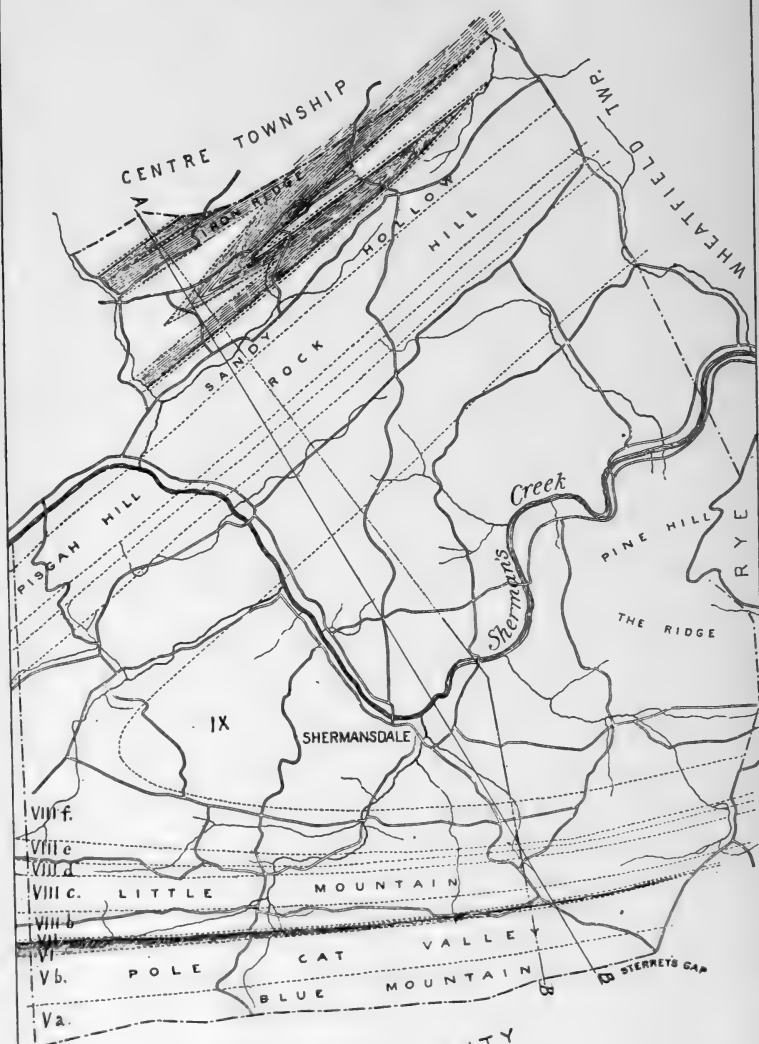
There is no trace of a fire-clay either above or below the coal seams.

The coal is soft, and crumbles to powder between the fingers. No great quantity appears to have been taken out. No one seems to know much about it, and all the spoil has been removed and used for embanking the canal.

A few feet below (south of) the coal is a mass of yellow ochreous shales, 8 or 10 feet thick.

The position of this coal is about the middle of the Pocono sandstone, and corresponds in a general way to a portion of the group of coal measures cut by the railroad tunnel through Sideling hill in Huntingdon county, described in Report F, page 209, 1878. Had the money been spent in running a tunnel into the hill across the strata, much might have been learned of their contents.

Carroll township.

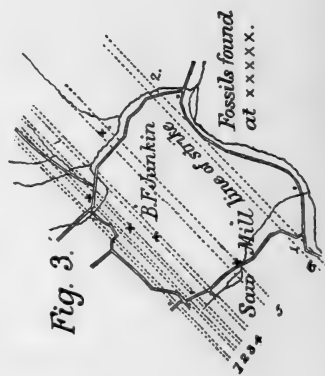
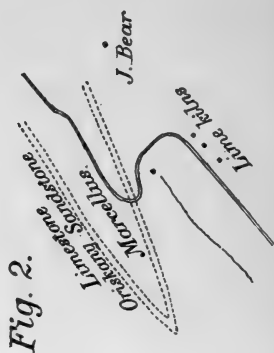
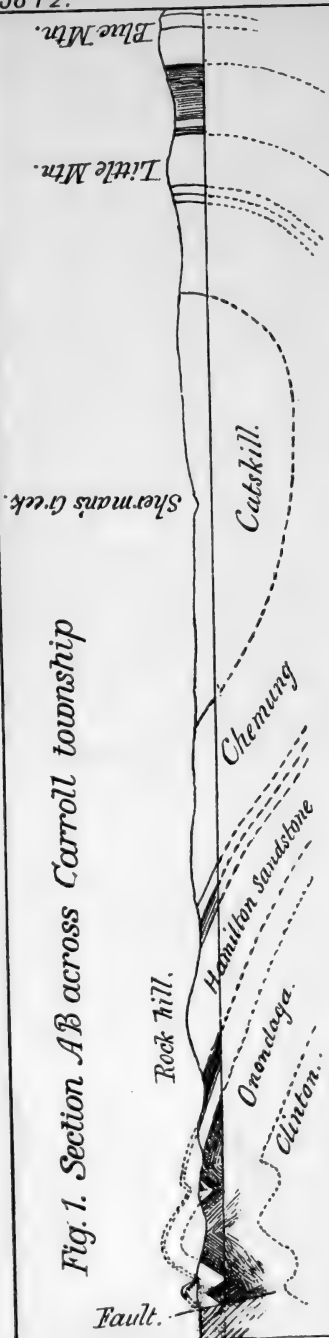


2. Carroll township.

Carroll is one of the large townships in the county. It is bounded on the north by Centre and on the east by Wheatfield, Penn, and Rye. The crest of the Blue or Kittatinny mountain is its limit on the south and on the west a small stream, Richland run, rising in Centre and flowing south to Sherman's creek, then for a short distance Sherman's creek itself, and further on an imaginary north-south line to the Blue mountains separate it from Spring township. It is not mountainous, the greater part of its surface lying in the great undulating plain contained between Pisgah hill and Little mountain. The northern part of the township, however, is occupied by the range called Pisgah hill, and the southern part by the more rugged Little mountain and Blue mountain, between which latter lies the long and narrow Polecat valley. Its length and breadth vary much in different places, but may be set down approximately as 8 miles and 7 miles respectively, giving an area of rather more than 50 square miles.

The chief draining stream of this township is Sherman's creek, which traverses it from west to east almost in the middle. Its course is very sinuous, and its basin includes, with very small exception, the whole of the township, the waters from south and north meeting in its channel.

Sherman's creek flows for several miles along the north foot of Pisgah hill, but about a mile from the point where it enters Carroll township, it passes through the ridge, forming a picturesque gorge several hundred feet deep and displaying a fine curving cliff of Hamilton sandstone rocks on the west side. On the east side a high projecting knob of rock almost bars the passage for the stream. This has been quarried away in making a road, and is locally known as Gibson's rock, being named from Chief Justice Gibson, whose homestead is close by the place. This gorge is a common resort for picnic parties from the surrounding county. East of the stream the range takes the name of



Rock hill from the cliff just mentioned. Soon after leaving this point the stream comes upon the olive shales of the Chemung, near Dr. Drumgold's tannery, and then upon the red sandstone and shale of the Catskill, near Shermansdale mill, upon which it continues for the rest of its course.

In this township occur some of the most fossiliferous exposures of the Kingsmill sandstone, chiefly, however, as loose blocks for the bed rock is seldom seen.

On the border between this township and Rye lies the great highway from Perry county to the south—Sterrett's gap—formerly more used than now. To this point converge the roads on both sides of the mountain, passing over at about half the average height of the range.

The Perry County fault.

This fault passes through the northwest corner of the township throwing up the Lower Helderberg limestone against the Hamilton upper shale or the top of the Hamilton sandstone. The contact is not exposed but the presence of the fault is evident in the close juxtaposition of the Marcellus iron ore and the Hamilton sandstone. The throw here is about 1200 feet. For further details see the chapter on the faults of Perry county.

The Medina sandstone.

In Carroll township the Medina makes little or no show, the county line throwing all or nearly all of its outcrop into Cumberland county. It is thin and makes with the iron sandstone the buttresses of the mountains, an account of the structure of which may be found in the report on Rye township.

The Clinton group.

Little can be seen of this group in the township. The fields near Sterrett's gap expose the lower green shales, fragments of which are brought up by the plow. There are indications of two thin beds of poor iron ore on the land of Mr. Burn, which are interesting by rendering more exact the correlation of these lower shales in Perry county with the same beds farther north. The iron ore beds just men-

tioned probably represent here the Block ore and Bird's-Eye fossil ores of Shade mountain.

Polecat valley gradually widens to the westward by the coming in of the limestone and shales, and also by the increasing thickness of the Onondaga, but through this township the Clinton group is mostly covered with timber and difficult of examination.

The Onondaga group.

As the shales of this group flatten down and also attain their full thickness, the Polecat valley which is due to their erosion, widens out and is cleared of timber and cultivated. The beds at the top of this group—the variegated and grey shales—reach their full development in the western part of this township. But I have been unable to trace their gradual increase or determine their lower limit.

The Lower Helderberg group.

The rocks of this group which first appear near Sterrett's gap (the flint shales) gradually increase in thickness westward, lower beds continually coming in until near the middle of the township the upper part of the group has become solid enough to yield limestone for the kiln at Mr. Brownell's. The beds here are soft and much decomposed at the outcrop. The lime has been much dissolved out. They are fossiliferous and yielded me several of the species common in the lime shale. The lower part of the division including the more solid limestone beds does not make an appearance at this point. The rocks of this group however make a noticeable ridge along the valley which becomes very conspicuous farther west. The limestone has been very largely quarried and burnt near the north line of the township at Mr. John Bear's. The coral bed is here largely developed and the corals silicified. See section below.

Bear's limestone quarries.

The quarries from which a large quantity of limestone has been taken occupy the same horizon as Garber's quarry

at Falling Spring. They are some of the largest in the county. The beds from which the lime is obtained are the lower beds of the limestone shale in No. VI. These beds are almost barren except the coral bed which is as largely developed here as at Garber's quarry and the corals are more silicified. They occur in the highest bed in the quarry, and good specimens may be obtained from a small hole in the field to the southeast.

The Oriskany sandstone (VII) crops out at the turn of the road north of the quarry and again on the other side of the field belonging to John Berry. Between these two lies a tongue of the Devonian slates and the Marcellus ore. See Plate XI, page 158, Fig. 2.

These two lines of Oriskany sandstone come from the road from New Bloomfield to Rattlesnake hill, returning from Ayl's lime quarry and the camp ground.

Smith's quarry and red ochre diggings.

At this point is shown the meeting of three different groups:—Marcellus limestone and lower ore; Oriskany sandstone; and Lower Helderberg limestone.

In the quarry occur the Coralline beds of the sandstone shales, with *Trematopora*, dipping *southwest*, and a few yards further up the road northeast. Between the quarry and the corner of the road may be found in the bank traces of the *Meristella* bed, but not well exposed.

The Oriskany betrays itself almost exactly at the turn in the road, and following it is a bed of red iron ochre from which many tons have been taken and ground down for paint, which is said to be of good quality. The seam varies from one to three feet in thickness and has been followed along the crop for about 80 or 100 feet, but no attempt is now made to mine it.

Next to this is a feeble show of the Marcellus limestone. In the field below some of this which has been thrown out from a small tunnel run about 25 feet in the search for ore.

Oriskany sandstone; Marcellus and Lower Hamilton shales.

These beds require little notice. They make no con-

spicuous outcrop and present no features of importance. All are probably present in full thickness, and by their disintegration contribute to the formation of the valley called Sandy Hollow.

The Hamilton sandstone.

The Hamilton sandstone shows two outcrops in this township, one of which forms a long straight line from E. N. E. to W. S. W. from the road between New Bloomfield and Delville to the township line near Falling Spring. This ridge is the real continuation of Dick's hill, with a trend rather more to the southward owing to the intrusion of the tongue of red shale, &c., that runs up from Bridgeport.

It is also a continuation in the opposite direction of Pisgah hill, but these names are not usually applied to this portion of the range. Common usage limits the term Dick's hill to the range in Wheatfield township, and Pisgah hill to that southwest of Sherman's creek, the intervening part being usually known as the Rock hill from its precipitous termination at Gibson's rock on Sherman's creek.

In this ridge the beds on the northern side dip very sharply, but the angle becomes less and less so that on its south side it seldom exceeds 30°. In consequence of this increase of dip the breadth of the range much exceeds the thickness of the bed of sandstone of which it is composed.

Like the other ridges of Hamilton sandstone, this is steep and covered with wood, especially on its northern side.

The only cut in Rock hill through which water passes from the north side to the south is Gibson's gap, which affords one of the most beautiful examples of the erosion accomplished by a small stream that can be found in Perry county. The bold peak of Pisgah hill, which here reaches its greatest altitude, shows the height of the barrier through which the creek was compelled to pass on its way to the sea. The steep hard cliffs of sandstone which rise on both banks show the nature of the obstacle. For nearly half a mile the stream winds along between almost perpendicular walls till it emerges from its confinement to wander more freely over

the softer shales of the upper Hamilton and Chemung groups.

The ridge road to Carlisle from New Bloomfield passes over the Rock hill at a place about two miles from the Rock where the crest is slightly lower than usual, but the depression in no wise deserves the name of a gap.

The road from the county-seat to Duncannon also passes through the Hamilton sandstone range at Rattlesnake hill, but here also the depression is slight. No water comes *through* it from the head of upper Sandy Hollow. The gap is only in course of formation and will require many thousands of years for its completion at the present rate of progress, the little stream which heads near its north side being capable of doing only a small amount of erosion on the sandstone.

The second outcrop of the Hamilton sandstone is on the south of the township where under the name of Little mountain it runs in an east and west direction parallel with the Blue mountains. The dip of the beds is here much steeper than farther north and the passes are consequently shorter.

The Hamilton fossil ore.

The bed or beds of this ore pass through the township along the southeastern slope of the Rock hill. Traces of the presence of ore may be seen in many places but none has yet been taken out. From fossil evidence it is probable that the three beds described in the account of Wheatfield township also occur here. Nor is there any reason to doubt their presence in Little mountain.

The ore bed has been exposed on the southeast side of the Rock hill on the land of Mr. Hicks but no attempt has been made to work it. Indeed it would probably be unprofitable. The ore is very fossiliferous, holding the same species as near Marysville.

The Hamilton Upper shale.

Good exposures of this bed occur along the south side of the Rock hill between the Hamilton sandstone and the road.

They are for the most part small ledges in the fields broken up by the plow. Some of them are very fossiliferous and have yielded most of the species found on this horizon in other parts of the county with some not yet met with elsewhere. The shale has apparently its usual thickness. Along the place of this outcrop in the south side of the syncline I have not seen any exposure but have no reason to suppose that it is not present. The two formations above the Hamilton sandstone next to be mentioned, though thin, are so far as I have observed persistent.

The Genessee, Portage and Chemung.

The shales of these groups are exposed in Carroll township along their expected line of outcrop, especially on the north side of the syncline. The characteristic fossils of the Portage shales may be found near an old mill on the south side of the road, about a mile from Drumgold's tannery. The shales present here their usual dark color and cross-fracture and apparently are of their usual thickness.

The Chemung shales cover a great extent of ground in this township, their outcrop forming a belt more than a mile wide from Rattlesnake hill to Mount Pisgah, and thence east to the line of Rye township. Their thickness is intermediate between that of the same group near Milerstown and near Marysville. In the western part of its outcrop this does not exceed 2700 or 2800 feet, about three times its amount at the Susquehanna gap. Their surface presents the usual rounded hillocks and poor soil without any geological features calling for farther notice.

The Chemung-Catskill beds and Catskill group.

The middle of the syncline in Carroll township is occupied by the red sandstones and shales of this group, mostly with a low angle of dip and curving gradually around to return eastward to the Susquehanna along Fishing Creek valley. They show none of the thinning out that marks those of the Chemung in the southern and southeastern part of the county, and their outcrop consequently underlies a wide tract of country. The rocks dip south-southeast

in the northern part of the township, east in the central, and north in the southern portions, passing everywhere under the Pocono sandstone of the Cove mountain.

The lower part of these rocks consists of soft shales and sandstone which, by disintegration, yield a warm and fertile soil far superior to that on the adjoining olive shale of the Chemung group. But their upper part consists of the harder sandstone bed which skirts the outcrop near the foot of the Pocono mountain, and form Pine hill, a wooded ridge encircling the sandstone outcrop, to which it is an outer line of circumvallation. A narrow valley lies between the two ramparts, the water escaping by a gap near Grier's Point, in Rye township, into Fishing Creek valley.

The terminal point of the syncline rises in a conspicuous knob opposite the end of the Pocono sandstone of the Cove mountain overlooking Sherman's creek to which these hard beds form a barrier until near Duncannon it succeeds in passing through them about a mile from its mouth.

The Kingsmill sandstone.

Entering from Wheatfield township this bed passes west-southwest without any very strong show for nearly a mile. It then crops out as a strong ridge on or near the land of the Hon. Judge Junkin. It is here very fossiliferous but the species are in great part different from those which occur at the other exposures described in the account of Wheatfield township.

This bed continues towards Sherman's creek where abundance of loose blocks reveal its presence near Shermansdale mill on the grounds of Mr. William Borroll and of Mr. S. Grier. The fossils are abundant and in excellent preservation, brachiopods, which were rare farther east, being here plentiful. They are very ferruginous and of course only occur as casts. The persistence of this ridge over so great an extent of country renders it a very valuable horizon. I have not found it so rich in fossils along its south line of outcrop in Carroll township, but this is also true of it in the northern and northeastern townships where though rec-

ognizable without the slightest doubt fossils are comparatively scarce.

Section of beds in Chemung-Catskill sandstones and shales, on the farm of the Hon. Judge Junkin near Delville. See map on Page Plate XI, page 158, Fig. 3.

Chemung-Catskill passage-beds.	6.	Delville green sandstone—a massive bed about twenty feet thick and upwards, containing in its middle a bed of plant remains sometimes very thick.
	5.	A bed of brown or brick-red sandstone not shown in place but indicated by numerous loose blocks at the saw-mill and containing fossils.
		Brown sandstone, indicated by stones in a pile on the side of the road northwest from J. Speace's, possibly same bed as 5.
Chemung.	4.	White or pale yellow sandstone on the top of the ridge immediately north of the house on Judge Junkin's farm, showing in place in a field to the west. Kings-mill sandstone.
	3.	Brown sandstone, indicated by two or three large blocks on road from public highway to the farm-house, completely filled with casts of <i>Spirifera mesocostalis</i> , &c.
	2.	Brown sandstone on road between Rhinehart's brick house and the fork in the road to the north of it.
	1.	Green shaly bed about ten inches thick, full of Polyzoa and Poteriocrinus.

Section on Sherman's creek at Shermansdale mill

Dip, 15° < S. 50 E.

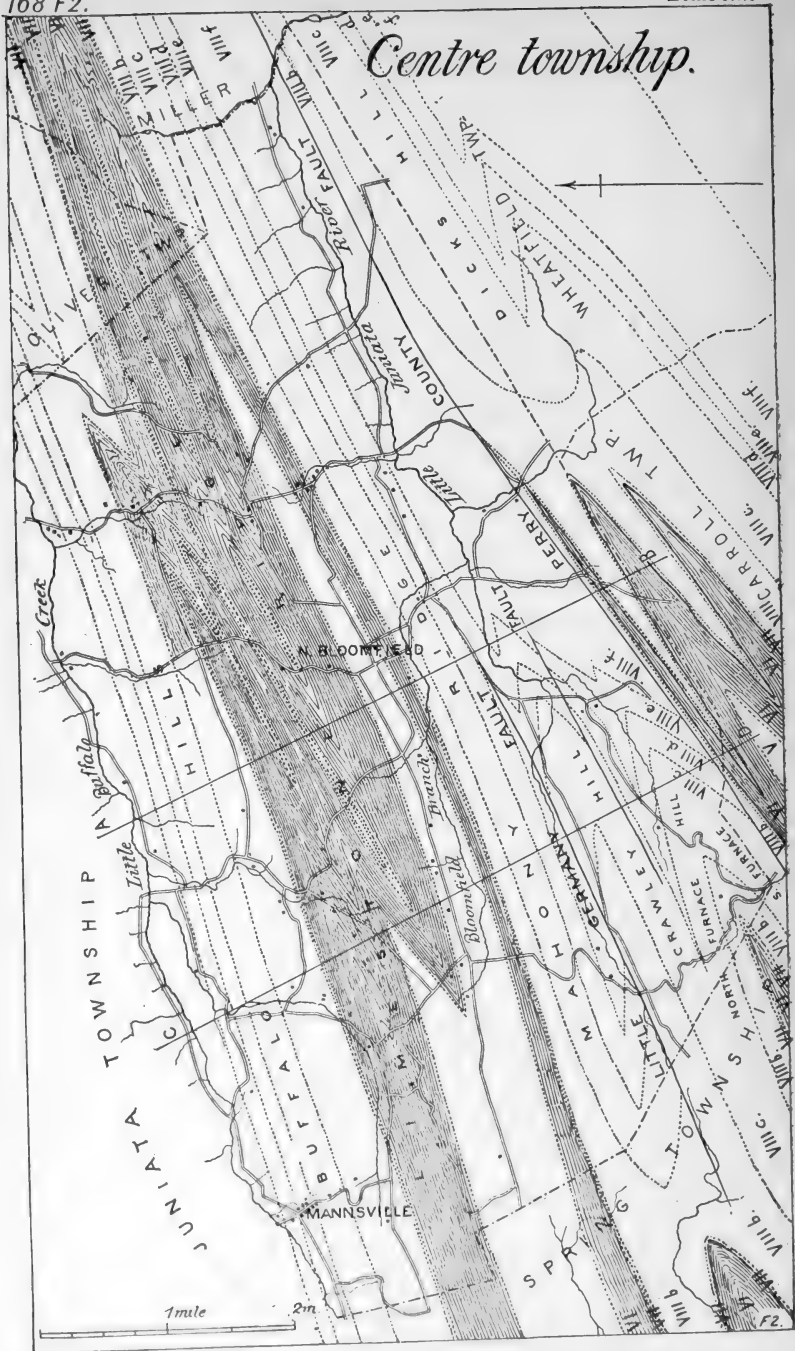
Green sandstone with green shale pebbles and a bed of coaly matter in the middle, thin-bedded at base with coaly matter and plant-rags, (Delville green sandstone.)? . . . 20' 0'		
Green shale,	1	0
Red shale,	5	0
Brown sandstone and shale.		
Space concealed about 150 feet.		
Gravel occurs here 10 or 12 feet above the water.		
Green shale with black iron stains,	4	0
Brown sandstone,	10	0
Green sandstone, massive in thin beds with plant-rags.		
This sandstone also much resembles the Delville sandstone.		
Space concealed, not great.		
Green sandstone, soft, with casts of shells.		
Red shale and brown sandstone,	30	0
Green shale,	0	6
Soft green sandstone weathering yellow,	2	0

Greenish white shale with plant-rags,	3	0
Yellowish white sandstone with sandy shale and plant-rags,	6	0
Green sandstone with sandy shales,	4	0
Red shales,	8	0
Green sandstone, 4 beds, with thin sandstone partings,	4	0
Green sandstone with plant-rags,	2	0
Green and yellow shale with plants almost forming a thin coal bed,	1	6
Red shale,	3	0
Green shale with plant-rags,	1	0
Red shale.		

The beds shown in this section lie above those to the east of this road on the land of Mr. Borroll and Mr. Grier. Judging by eye and taking into account the small dip, they must lie about 300 feet above them. The whitish Kingsmill sandstone with its fossils should cross the road in the ground north of the mill; but so many stones have been hauled here for the purpose of protecting the land from the ice that it is impossible to distinguish them from the rocks in place. The ice, too, has brought down quantities of large boulders and scattered them along the bank.

Above the mill and for some distance below it the creek is working to the westward and cutting away its right bank. Below that point to the bridge the other bank is being washed down.

On the opposite side of the creek and above the mill are some fossiliferous beds in the green shale and red sandstone which have yielded a *Lingula* and some other fossils not yet identified, but indicating transition beds between the Chemung and the Catskill.



3. *Centre township.*

A. *General description.*

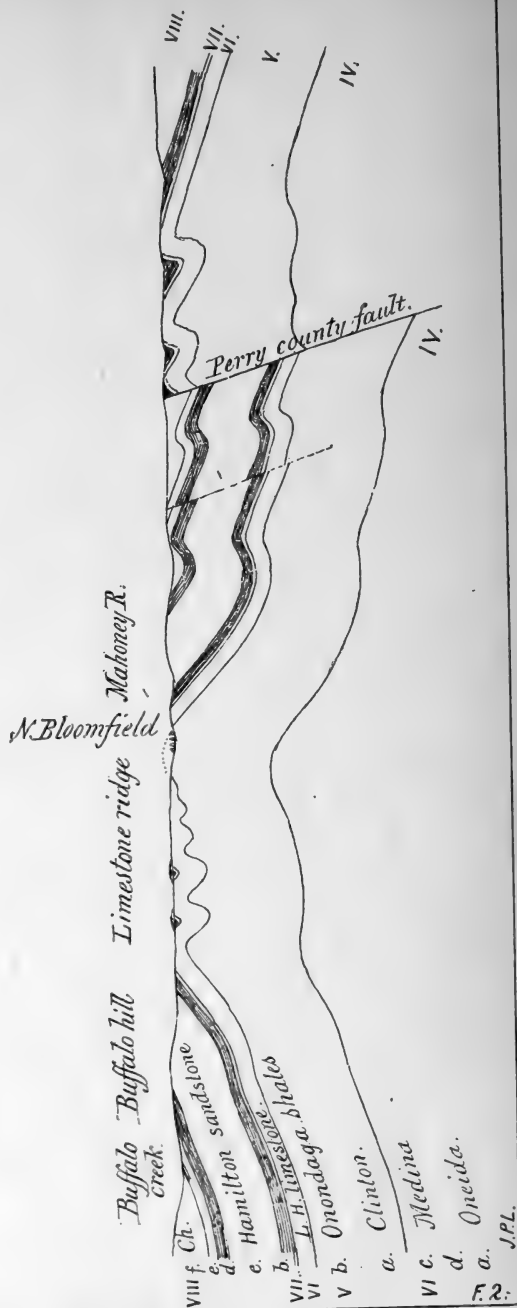
Centre township is bounded on the north by Little Buffalo creek, which divides it from Juniata and Saville. On the west lie Saville and Spring. The Carroll and Wheatfield line follows the crest of Iron ridge and Dick's hill. Horting's run parts it from Oliver and Miller. Its extreme length from east to west is about eight miles and its greatest breadth from north to south about four miles. Its area is about thirty square miles.

The only town it contains is New Bloomfield, the county-seat, lying very near its center and containing about six hundred inhabitants.

Centre township affords a good type on the small scale of Perry county. Its surface is broken by ridges of high ground ranging from east-northeast to west-southwest. The most northerly of these skirts the south bank of the Little Buffalo and is called the Buffalo hills. It consists of a succession of steep-sided heights well clad with small timber and separated by deep, narrow ravines or gaps, locally called "narrows," where the hemlock-spruce and other shade-loving trees find a congenial home. Some of these passes afford the most beautiful bits of scenery in Centre township. A narrow road usually winds along beside a small brook and is often completely overhung with spruces and pines. Here may be found in profusion the sword-fern, (*Polystichum acrostichoides*,) the common Polypody, (*Polypodium vulgare*,) the ebony spleenwort, (*Asplenium ebeneum*,) and other plants that delight in coolness or moisture.

Limestone ridge running almost parallel with the preceding consists of a number of minor ridges with intervening valleys. The passes through this range present none of the

Section line A-B across Centre township. → S.E.



beauty of those through the Buffalo hills, being less deep and narrow and usually cleared of timber. Limestone ridge passes at a short distance north of New Bloomfield and is capped in many places with rugged, moss-grown pulpit rocks of the Oriskany sandstone, forming long, straight ridges. Graywethers of the same material dot the fields and woods on both sides of these ridges and bear witness to their former wider extent.

The vale of New Bloomfield lies between Limestone ridge on the north and Mahanoy ridge on the south. It is the most fertile portion of the township. The soil is comparatively rich and warm, and being mostly under cultivation yields good returns.

Mahanoy ridge passes immediately south of New Bloomfield. It is high, often steep, and well covered with small timber. The gaps in this range, though shorter, resemble those through the Buffalo hills, being narrow, winding, and dark with spruce and pine. The meaning of the name is unknown but it is probably of Indian origin. It occurs in Northumberland county as the name of a creek and of a small town standing upon its banks. Another Mahanoy is a station of the Catawissa railway on Catawissa creek in Schuylkill county. The word is usually pronounced with a guttural sound as if it were spelled "*Machonoy*, the *ch* having the Scotch or German sound. A connection may hence be inferred with the name Mauch Chunk where the *ch* is pronounced in a similar manner.

There is much more picturesqueness in the geography of a county when the names of the great and abiding features of the landscape—those that remain while men come and go, "the everlasting hills," the valleys and rivers—bear the names bestowed on them by a race that has passed away. Such names are fossils, superficially meaningless to the present inhabitants, but showing when studied a significance and richness of association that no name of recent signification can contain.

The slopes of Mahanoy are tilled only up to a small height, as their upper parts are too steep to render cultivation profitable.

Section line C-D across Centre township. → S.E.

Buffalo Cr. → Buffalo hill Limestone ridge Mahony ridge. Crawley R. Furnace hill.



A wide open valley separates Mahanoy ridge from Dick's hill and Iron ridge, along the crest of which, for the most part, runs the township line. The soil of this valley, being composed of disintegrated Chemung shale, is less fertile than that of the vale of Bloomfield, but contains, nevertheless, some good farms.

This southern valley of Centre township is broader than the valley of New Bloomfield, for causes which will more clearly appear when the geology of the township has been described. Though undulating, its surface is seldom steep, and it is well watered by springs and streams. Moreover the shaly soil and sub-soil are more retentive of moisture than is the limestone of the northern ridge.

Cultivation has been carried up the slopes of the hills in Centre township as high as at present would be profitable, and in some cases higher. The labor of clearing the stones from the hillsides is very great. Two crops of them may sometimes be gathered annually and yet there are plenty left for the future. Plowing softens the ground and enables the rain to carry the soil down to the lower levels. In this way new stores of stones are, year by year, brought into view on the upper part, while on the lower slopes few are visible at the surface. In the woods, also, where the wash is prevented by the roots and leaves there is often—not always—a fair covering of soil until the timber is felled and the plow begins its work. The huge piles of sandstone and chert that almost surround some of the hillside fields—euphoniously termed in the district flint-gravel—attest the labor spent in clearing the land. In general this is only done where a limestone sub-soil exists. Where sandstone is the basis the land is usually poor and thin, and does not repay the outlay.

The soil is deep in many parts, especially on the lower grounds and along the courses of the streams. Occasionally this is true among the hills. But where the slope is steep or the brow of the rising ground prominent, the rock will usually be found at a small depth—a few inches often—below the surface. In these cases the outcrop of the beds may be readily traced by the fragments thrown out by the

Marcellus ore, north of N. Bloomfield.

Fig. 1. Local map.

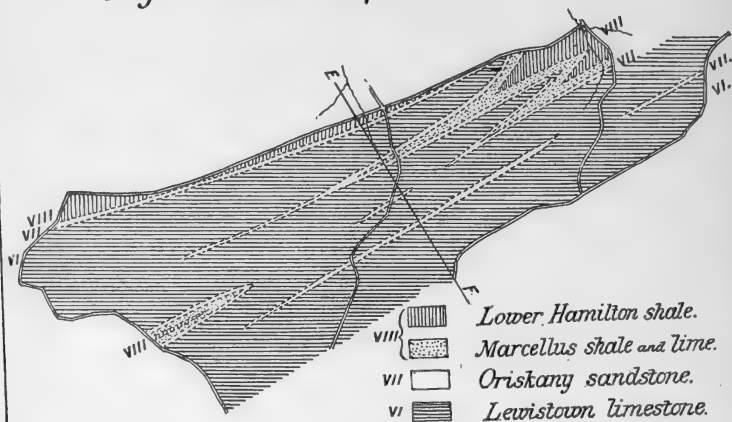
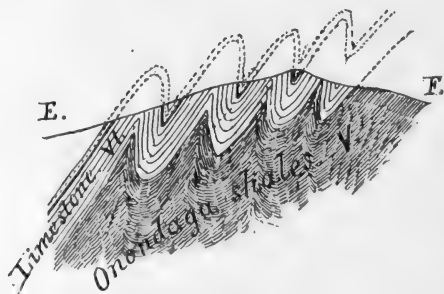


Fig. 2. Cross section.



plow. Here cultivation usually ceases, the soil being too thin to repay the labor.

Continual plowing of the hillsides for many years has also been attended by its usual consequence. The soil has been thrown down-hill one furrow's breadth every time, and the higher part gradually bared to the rock. The soft soil exposed on a steep slope has been washed by the rain to lower ground, so that many hill-fields formerly cultivated have been abandoned, and are now going back to forest and becoming covered with a new growth of scrub pine (*P. inops*.) This is the best use to make of such land. The ridges and hills of Perry county if carefully managed by men skilled in woodcraft would yield a better harvest with less labor than can ever be obtained from them by the use of the plow. The present plan of cutting them over occasionally—clearing them and coaling the wood—is not the most profitable method of turning forest land to account. While it is not probable that the most valuable kinds of timber, such as black walnut, will ever be grown, except in some lowlands in the county, yet the hills would yield under good management perennial crops of white oak, maple, and chestnut, becoming every year of greater value in consequence of the growing scarcity of wood. Many of them might also be planted with the white pine and locust, and would yield a speedier return.

It might be quite worth the cost and labor of the experiment to attempt the introduction of the European larch, (*P. larix*,) a tree which grows rapidly on dry hillsides and yields a timber of great value. Many thousand acres of waste mountain land in Scotland have been thus converted from desolate, almost worthless property, into green and wood-clad slopes and craigs, yielding their planters (the Dukes of Athol) a revenue that could have been obtained from them in no other way. The disease now prevailing among the larch plantations of Scotland may also contribute to render its growth of greater importance in America. Care should however be taken to avoid importing the parasite, lest as has happened in several similar cases the mischief should exceed the gain.

Iron ridge north of N. Bloomfield.

Fig. 1. Cross section.

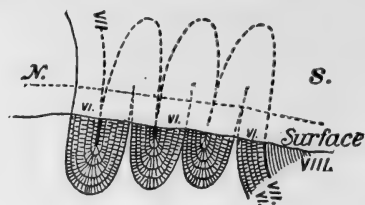


Fig. 2. Ore deposit.



Fig. 3.

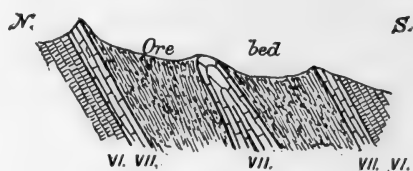
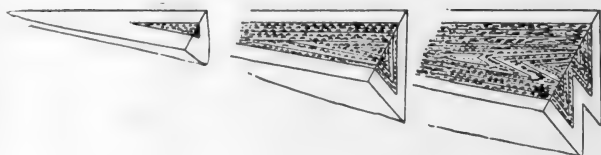


Fig. 4. Disappearance of the ore worked south of Newport, westward.



Centre township possesses no large stream. Its southern valley is drained by the Little Juniata, which rises in Spring township and flows between Mahanoy and Crawley hill, then between Mahanoy and Iron ridge, and lastly between Mahanoy and Dick's hill until it reaches the gap near Montebello furnace through which it passes and continues in a southeasterly direction to meet the Susquehanna at Duncannon. The Bloomfield branch of the Little Juniata rises in the west of the township and drains the vale of Bloomfield, passing immediately south of the town where it receives the waters of the "Town spring" and a number of smaller ones, and flows through the gap in Mahanoy ridge to meet the larger stream.

All the waters north of Limestone ridge, in Centre township, and most of those that rise among its branches and spurs flow away to the north and pass through one or another of the gaps above mentioned in the Buffalo range till they meet the Little Buffalo. They are insignificant in size, but some of them supply mill-power as they flow through the narrow defiles.

B. Geological description.

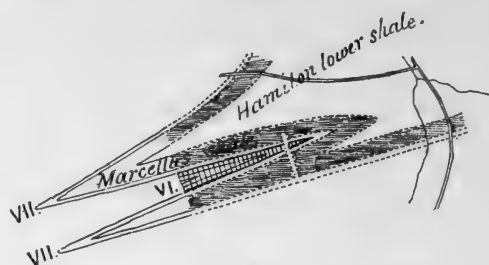
The rocks of Centre township, like those of Perry county in general, have been subjected to violent compression and crumpling, and stand at all angles up to and even beyond the vertical, being in some cases overturned, so that what was their lower side is now the upper.

The Onondaga variegated shale. (No. V.)

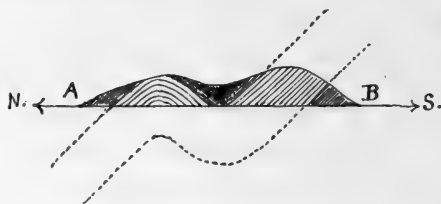
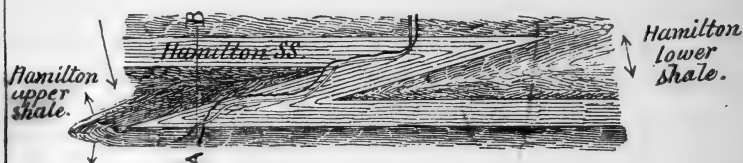
These variegated beds of the vale of Bloomfield, the lowest or oldest in Centre township, occupy a strip along the middle of the township about three quarters of a mile wide at its western line, narrowing to nothing at the east.

The upper part of the group consists of alternating layers of yellow-greenish and red shale none of them very hard but containing thin beds of sandstone which form a long low ridge along the middle of the outcrop. The ridge may be traced almost continuously. It passes through the town of New Bloomfield, whence I have named it the Bloomfield

Reeder's ore at Juniata Furnace.



Inoculate run at Newport narrows.



Mahony ridge and Buffalo hills.



sandstone. Here its harder beds may be seen cropping out in the streets with an almost vertical dip.

The road to Newport lies for several hundred feet exactly on the southern edge of the variegated shale, and about half a mile east of the town is a low cutting which displays the alternations of color and hardness very distinctly. Farther east it lies south of the road bed but may easily be traced where the fields have been recently plowed, through the farms nearly to the township line on the road to Baileysburg.

This red and green shale lies in the upper portion of what was called, in the Report of the First Survey, No. V, and is the equivalent of the Onondaga salt group of New York, but to my knowledge has never yielded either salt or gypsum (plaster) in this county. It represents the middle portion of the group in New York which lies under the gypsum and salt bearing strata. (See Chapter III, page 53.

The Onondaga gray shales. (No. V.)

These beds make no conspicuous show in the township. They are apparently 200-250 feet thick but no measurement can be obtained. They form, with the variegated shales just described, the south slope of Limestone ridge, and extend under part of the flat land in the valley between the Oriskany and the Bloomfield sandstone, the latter being the upper layer of the variegated shale which forms a low ridge along the valley.

The Lewistown limestone. (Lower Helderberg, No. VI.)

The second geological formation in Centre township is the Lewistown limestone, so called from its great development near Lewistown, in Mifflin county.

This is the bed from which all the lime made in the township is obtained. It corresponds, as has been determined from its fossils, to the water-lime division of the Lower Helderberg limestone of New York.

It consists of a hard, solid, thick-bedded limestone, with a thickness near New Bloomfield of about 60-70 feet, from which it does not largely differ anywhere in the township.

It comes to the surface at many places, especially along the ridge, and usually shows a dark color when freshly broken, changing under the influence of the weather to a lighter tint, and is marked with very fine lines on the exposed edges, indicating the layers of original deposition. In many places it is very bituminous, giving out the characteristic smell when struck with the hammer. This smell is often described as "sulphury" by the quarrymen.

When burnt it yields a strong white hot or "fat" lime, but is much valued in the district for building, where the dolomitic or magnesian limestones yielding a cool or "lean" lime do not occur. For use on the land it is preferable to the latter kind, yielding results more quickly and needing less caution in its application. It has been very extensively used for many years past, and with excellent results. In most cases the farmers quarry and burn the stone themselves, lime-burning as a separate business having scarcely yet developed itself in the township. (See Chapter V.)

The beds of this limestone contain very few fossils in Centre township. They are mostly hard and smooth grained, and are preferred for this reason to the overlying strata by the lime-burner. In some places, however, they are crowded with the little crustacean common in the water lime rocks of New York, *Leperditia alta*.

Where the rocks of this group come very near the surface they are brought out by the plow in the form of thin, flat slabs beveled at the edges, that ring under the hammer. In many parts they lie so thickly on the limestone ground that it seems as if nothing could grow between them. This is not the case. Indeed, the limestone is seldom picked off the land unless it is wanted, and even then in consequence of long exposure it burns with such difficulty that farmers prefer to quarry new stone.

The outcrop of the *Lewistown limestone* may be traced on the map so easily that it would be tedious to describe here its curious zigzag course in Centre township. One remark, however, it is right to make. The limestone bed with the over and underlying shales, being only 300-400 feet thick and lying for the most part nearly vertical, it is

not at once obvious how it can occupy so great an area. But by studying the sections given in this report, and following them across the county along the indicated lines, the puzzle will readily be solved. The 400-foot bed of limestone, &c., has been folded and creased so sharply that its beds, as there shown, are often vertical and sometimes overthrown, as may be seen south of New Bloomfield at Barnett's rocks. Consequently fold after fold of limestone occurs close together, sometimes separated by a layer of sandstone pinched into the crease and sometimes without it. The limestone, therefore, extends over a much greater tract of country than its mere thickness would enable it to cover, and shows at the surface alternately its upper and lower faces. This, too, is the cause of the recurrence of sandstone ridges parallel or rudely parallel with each other at intervals of about 800 feet—double the thickness of the limestone.

Lewistown lime-shales, (No. VI.)

These beds overlying the Lewistown limestone are exposed in several places in Centre township, but with one exception, to be noted presently, the exposures are small and insignificant. The beds are seldom opened for lime because the more solid limestone underlying them affords it at less expense and in greater purity. The small accidental cuttings therefore in which these shales are displayed only serve to prove the extension over the township of the fossils found at the typical exposure which forms the exception noted above. This exception is a roadside cutting and at the same time a lime quarry which has afforded me a complete section through the shales. It is situated about two and one half miles northwest of New Bloomfield at the entrance of the gap leading through Buffalo hills to Manns-ville and Ickesburg. The shales are dipping at about 30° N. N. W. under the Devonian rocks and were once quarried for lime, though now abandoned.

To the section here shown all the others found in the county must be referred as to a standard. No other can be compared with it either in completeness or clearness.

The following is a detailed section of the Lewistown limestone shales as they appear at Clark's mill:

(a.) *Clark's Mill section. (Typical.)*

Yellow Flint beds.

- 8' Limestone beds with black chert.
- 1' bed with *Strophomena*.
- 20' with *Tentaculites* and *Brachiopoda*.
- $\frac{1}{2}$ ' Coral bed.
- 3' *Tentaculites gyracanthus*.
- 3' *Tentaculites gyracanthus* and some *Brachiopods*.
- 2'
- 1' Coral—*Trematopora*—solid mass.
- 2' *Rhynchonella* beds.
- 4' covered.
- 1' soft, uneven gray shales with few fossils.
- 5' covered—bed full of *B. granulata* on surface of slabs.
- 4' soft, greenish shales with limestone bands.
- 8' covered.
- 1' bed covered with very small *Chaetetes* and *Tentaculites*.
- 3' hard, dark limestone full of small *Chaetetes* and some *Brachiopods*.
- 6' covered.
- 1' Limestone beds.
- 1' Soft Shale.
- 8' covered containing *Leptaena* bed, *L. rugosa*.
- 3' Rough Shales.
- 4' covered.
- $\frac{1}{2}$ ' thin, smooth, even-bedded shale.
- 8' covered.
- 6' Coral bed containing *Stromatopora* and *Favosites*.
- 15' rubbly limestone—no fossils noted.
- 2' smooth, even-bedded limestone shale—no fossils seen.
- 3' covered.
- 1' shaly, soft bed—full of a *Syringopora*? and *Sphaerocystites multifasciatus*.
- 5' *Rhynchonella* bed—crammed with *R. formosa*.
- $\frac{1}{2}$ ' full of very small crinoidal relics with a few *Brachiopods*.
- 3' close, firm, blue limestone with *Rhynchonella formosa*.
- 3' thin-bedded, wavy limestone, several thin beds crammed with *Murchisonia minuta*. *Murchisonia* beds.
- 12' shaly limestone weathering into rounded lenticular nodules, with a few *Beyrichia* and *Rhynchonella* and toward the top a few *Murchisonia*.
- 4' coarse limestone full of *Beyrichia notata*, Hall.
- 3' thin-bedded yellow limestone.
- 5' blue thin-bedded limestone.
- 1' thin-bedded limestone—*Leperditia alta* abundant.
- 40' ground covered.
- 50' thin-bedded limestone, dark, containing no fossils but the little *Entomostracan, Leperditia alta*.

Waterlime. Beds thinner toward the top.

(b.) *Clark's Mill section (fossil beds.)*

Silicified crinoid stems, &c.

- 8' Limestone beds with chert in the middle.
1' *Orthis oblata*, Hall, rather abundant.
3' Bed with *Tentaculites gyracanthus*, Eaton.
1' Bed full of *Cladopora fibrosa*?
6'' Bed with *Beyrichia granulata*, Hall.
1' Bed with small Chaetites? and *T. gyracanthus*.
8' Bed with *Leptaena rugosa* and *Calymene*.
6' Rubbly bed with *Stromatopora* and *Astrocerium*.
3' Soft shaly bed with *Aulopora*? and *Sphaerocystites multifasciatus*, Hall.
5' Soft shaly beds full of *Rhynchonella formosa*.
" *mutabilis*.
Spirifera Vanuzemi.
Cornulites,
3' Thin-bedded limestone with layers of *Murchisonia*
4' Coarse limestone full of *Beyrichia notata*, Hall.

Other exposures.

Beside the typical exposure at Clark's mill the following should be noted :—

(a) A small quarry on the top of the hill above Mr. Arnold's farm-house, a mile west of Bloomfield, shows the Tentaculite and Meristella beds abounding in fossils; thus—

Section of *Tentaculite* beds at exposure (a.)

- 2' 0" Thin shaly limestones—silicified Brachiopods.
 2' 0" Thin limestone—fossils not abundant, *Tentaculites*.
 6" Limestone with small polyzoa and shells—*Tentaculites*.
 5' 0" Thin-bedded limestones with Brachiopods and Tentaculites,
 a Trematopora? bed near middle, and a black bed crammed
 with brachiopods about 1 foot from base.
 Rough rubbly shaly stone flaking off, full of *Meristella*
laevis much crushed.

(b) In the woods on the top of Limestone ridge north of New Bloomfield and on the old road to Newport is a small quarry also showing the *Meristella* beds.

(c) The Meristella beds may also be seen in the wood a few hundred feet east of Mr. Adam Clouser's house.

(d) A small show of some of the beds occurs on the road to Newport near the top of the ridge.

(e) The fossils of the limestone shale occur along the top

of the hills west of Bloomfield near Clark's mill for a mile or so.

(f) Near the ore banks of the old Juniata furnace is a quarry in the lime-shales, of where may be seen

- 5' 0'' *Rhynchonella* beds, soft greenish shales.
- 1' 0'' Shaly limestone.
- 1' 0'' Solid limestone, silicified corals.
- 5' 0'' Rubbly limestone, no fossils distinct.
- 2' 0'' *Murchisonia* beds.
- 2' 0'' Solid limestone.
- 7' 0'' Thin-bedded shaly limestones with silicified *Meristella laevis*, *Streptelasma*.
- 3' 0'' Lenticular limestone without fossils.

(g) On the top of Limestone ridge, north of Mr. O. Rice's house, are some abandoned quarries, where may be seen

- 6' 0'' *Rhynchonella* beds, soft greenish shale.
- 2' 0'' as next below but thin bedded.
- 1' 0'' Limestone, fossils silicified.
- 6' 0'' Rubbly limestone with few fossils.
- 1' 3'' *Murchisonia* beds.
- 1' 0'' Limestone, no fossils.

The Oriskany sandstone, (No. VII.)

No geological formation in Perry county can vie with the Oriskany sandstone for picturesqueness. The smooth, rounded outlines of the shale and limestone hills and great valley are attractive and profitable to the farmer, but their beauty is that of repose and quiet. The wild, rough, ragged, and moss-covered pulpit rocks of this formation standing up in long, narrow lines across the county, have a grandeur and sometimes a majesty which can never be found in smooth and cultivated ground. Perhaps no one of these equals the well known Pulpit rocks of Warrior ridge near Huntingdon, but those who explore the woods and wilder parts of the county are well aware that they conceal displays of Oriskany pulpit rocks finer than any that can be seen near the roads and other frequented places.

The Oriskany sandstone in Centre township is thin, seldom or never exceeding 20 feet in thickness. This thinness prevents its forming high hills or mountains, such as those made by the outcrop of the Medina and Hamilton

sandstones. It usually shows itself as a ridge of rocks upon the surface. The frosts and storms, the suns and rains of the ages have split the solid rock into pieces and the same process is still going on. The larger fragments are being broken into smaller ones and the smaller ones into sand, which is washed down and carried away by the river as fast as it is formed. Nothing but their greater hardness has saved them from the more rapid destruction which has been the fate of all the softer beds in the vicinity.

But, though thin, the Oriskany sandstone is a conspicuous feature in the geology of the township. The great number of its outcrops renders its ridges very numerous and in some places they seem almost in contact. The lateral or tangential pressure to which I have alluded as the cause of the foldings of the rocks was more severe, or, to speak more accurately, the effects of its severity are more apparent in Centre township than anywhere else in the county. The beds of rock in many places stand vertical and are sometimes overthrown.

These facts may be best observed on Limestone ridge and in Dick's hill and Iron ridge. As mentioned above the limestone bed of which these ridges consist is not more than 400 feet thick, including the adjoining shales. Consequently as this bed, sharply folded and lying in a vertical position, covers tracts of country sometimes half a mile wide there must be many folds in that space. Now, every fold of the limestone involves a fold of the overlying Oriskany sandstone. A geologist therefore would expect to find a series of nearly parallel ridges crossing the county at intervals ranging up to 700 or 800 feet. This is actually the case, as may be proved by any one who will take the trouble to walk across Limestone ridge or Iron ridge at right angles to the strike of the beds, or from N. N. W. to S. S. E. (See sketch section, Plate XVI, page 176, Fig. 1.)

Three complete folds of the Lower Helderberg limestone and Oriskany sandstone are here shown. They are crushed and pressed close together so that their sides are nearly parallel. The Oriskany sandstone is represented by the black line on the top of the limestone. It is observed that this

sandstone will form a ridge at every fold. The most southerly ridge has been removed by the erosion of the surface. When the land stood at the level represented by the dotted line the three ridges were present. When it shall have been cut down to a lower level than at present the second ridge will disappear, and at a later period the third ridge, now the deepest, will have been removed.

In this way it comes to pass that a wide extent of country can be occupied by a bed of limestone seemingly or really continuous though only 400 feet thick. This is the case on Limestone and on Iron ridges and in several other places in the county. For the most part erosion of the land by weather has not proceeded far enough to cut out altogether the ridges of sand rock, which may therefore be traced running side by side with the intervals given above. They are not always continuous. One will stop and its place be taken by another or by two, according to the number of rolls in any cross section.

In some places the Oriskany sandstone is a conglomerate of small rounded quartz pebbles resembling in size and appearance little white beans. These are mixed with a small proportion of larger ones, but no very coarse material has been noticed in Centre township. Usually this conglomerate is hard, but at certain spots, such as the exposure nearest to New Bloomfield on the south of the cemetery, it is soft and crumbling, so that it is easily quarried and crushed and the constituents separated. The pebbles were formerly used for rough-casting the frame houses in the town. Little of this is now done, weather-boarding having taken the place of rough-casting or pebble-dashing. The sand from this bed, if fine enough, as is often, perhaps usually, the case, is used in making mortar. Sand for this purpose would otherwise be difficult to obtain in the south of the township, as there are no streams capable of making and accumulating it. It is worthy of notice that the sand grains of which this sandstone is composed are not sharp like those of a grit-stone, but well rounded and smoothed, showing that they have been ground down with the pebbles on an old beach just as the same materials are now ground down on the

beach of an existing ocean. The sand may, therefore, be considered the relics of pebbles that have disappeared, and the pebbles the remains of greater ones which only exist by the law of the survival of the hardest. Whence the sand was obtained to form this ancient Oriskany sea-beach is a question which cannot be here discussed for want of space.

This local softness of the Oriskany sandstone is one of the causes of the disappearance of the ridges in many places where antecedently they would be expected. Many such instances may be observed by any one who traces out the lines of this formation in the field.

The Oriskany iron ore.

In many places the Oriskany sandstone is deeply stained with iron. Some of its layers are very ferruginous. Blocks often occur completely covered with a black shining crust, which consists of the hydrated oxide of iron or brown hematite. These pieces have raised fallacious hope of the discovery of beds of iron ore in this rock. But such hopes have always been disappointed. No deposit of ore is known to exist in the Oriskany sandstone in Perry county, and with the exception of a bed to be presently mentioned none exists immediately above or below it. Though the sandstone ridges may with care be used as a guide to ore, yet they themselves contain no useful store of that mineral.

The enlarged local map of outcrops north of New Bloomfield, page plate XV, Fig. 1, will show the complex structure of the country immediately north of New Bloomfield, and at the same time serve as a guide to the iron ore bed at the base of the Marcellus black shale. Land owners in the district shown will be enabled to determine, by examining the map, whether or not this ore bed can be found on their land. At the same time the quantity and quality of the ore can be discovered only by digging. There is no other known means of proving the thickness or quality of any bed of iron ore, and all who claim the possession of any such means are claiming what they have not. I cannot too frequently repeat that the geological map can only show the place and not the quantity or quality of the ore. Yet

if a man is thus saved the expense of seeking what he will never find he is so far a gainer.

The first and most striking feature of the map is the extension of long tongues of the *Oriskany sandstone* through the Lewistown limestone. Between the northern and southern lines three such tongues may be counted. The first comes down from the northeast, at the road-junction near the Old Juniata furnace and runs for about two miles. In this trough or syncline the Marcellus ore bed must lie, but in this part of its course no ore is worked, nor can I learn that any has been discovered. The ground is low for the most part at the northeastern end, and the ore may be deeply buried beneath superficial wash. About a mile to the southwest, however, a considerable quantity was mined under cover some years ago and washed in the stream about half a mile away. Farther west than this no ore probably exists. The syncline becomes narrow and close, and after running as a single ridge for nearly a mile, is finally cut out by erosion near Poplar Hill cemetery.

Immediately south of the last and running southwest is another syncline also narrow but yielding ore in much greater profusion. Immense quantities were taken out to supply the Juniata furnace when in blast. The holes still remain on both sides of the road. Narrowing rapidly this trough of sandstone thins out and ends in a point about a mile from the road. But in this V-shaped place are situated Reeder's ore works, from which more is extracted than from any other in Perry county at the present time. The tunnel by which access is gained is situated on the north side of the ridge of Oriskany sandstone, through which it has been driven to reach the syncline containing the ore. In this way good drainage is secured for the workings, and the removal of the ore rendered easy. Further details may be found in Chapter V, on the iron ores and in the account of the Marcellus ore bed in Centre township.

This syncline is cut out by erosion at a short distance further southwest, then faintly reappears, but shows itself much more distinctly on the road from New Bloomfield to Markelsville, where it forms an open syncline and contains the

ore bed. Some attempts have been made lately to prove the ore, but without success. Nevertheless there is no question of its existence, especially on the land of Mr. W. Garling. Further search can alone determine if it is thick or thin, good or worthless. Indications, however, on the surface are against its proving valuable. The ridge of sandstone and ore is cut off about a mile further, the limestones taking their place near the house of Mr. John Power.

The other two sandstone ridges shown in the plan need a little notice. Both are synclines. The more northern begins about a mile northeast of New Bloomfield, and continues in a straight line for more than two miles westward, where it is cut out by erosion. The other is the end of the long ridge lying for the most part in Oliver and Miller townships, where it holds the iron bed and yields ore in great quantities. It begins just behind the school-house near Mr. O. Rice's house, and may be easily traced eastward to the Newport and New Bloomfield road which it crosses at the highest point between the two towns, the ridge here forming the watershed. Thence it continues through the wood for about half a mile, when it becomes double. At the place where the ridge becomes double a small displacement is visible which throws the eastern portion of the ridge about 100 feet to the south of the western part. This doubling is caused by the widening of the syncline so that the two walls come to the surface separately. Here also the dip of the north ridge is to the south, and that of the south ridge to the north indicating a change, for along all the western part of the ridges already described the whole parallel series dips to the north. A little further east the dip of the whole series is to the south.

It should be mentioned here that as soon as the ridge becomes double the Marcellus ore appears, showing its characteristic thin basal bed of fossil ore. (See Plate XVI, page 176, Fig. 2.)

Continuing about a quarter of a mile farther eastward the north ridge becomes very bold, rising at least 50 feet above the south ridge and presently shows a magnificent sheet of sandstone dipping 65° S. 10° E. It is the finest ex-

hibition of the Oriskany sandstone as a bedded rock in the township and perhaps in the county. Very soon after passing this cliff, for such it may be truly called, a third ridge appears between the two already described running out from the north ridge. The Marcellus ore bed immediately appears between this new ridge and that to the north, so that at this place there are three distinct sandstone ridges with two troughs between them each containing the hematite bed with its accompanying white and black clay.

The northern ridge is the highest, rising some 50 feet above the next, which in turn rises about as much above that on the south. For the geological structure of which these ridges and ore beds are the superficial indications, see Plate XVI, page 176, Fig. 3.

These ridges continue eastward. See Miller township.

Fossils.—Coarse and hard as is the Oriskany sandstone yet it furnishes evidence that the ocean on whose shores or shallows it was formed contained abundance of animal life. These coarse blocks are often honeycombed with the casts of fossil shells. The shells themselves have been dissolved and carried away by the percolation of acidulated water. But they have left cavities in the stone which indicate their former presence. It is not surprising if in the wear and tear of a sea-beach the thin and fine forms have been ground down and destroyed. This is the case in Perry county. But some of the heavier shells, such as the well known *Spirifera arenosa*, survived the rough usage to which they were subjected and were buried in the sand. But the relics of former life during the Oriskany age are very imperfect and scarce in Centre township. Nowhere in Perry county are they good. But in other parts of the State and in other States this rock has yielded fossils in great quantity and good preservation.

The Marcellus lime-shale and limestone.

These beds are only to be seen in a few places in the township. They are apparently well developed near New Bloomfield on the farm of Mr. Barnett, and their development is an argument against the pressure of the Marcellus ore in

any great thickness. Some years ago an attempt was made to burn some of them for lime but it proved a failure. The lime would not slake. As will be mentioned in the report on Madison township similar beds there yield lime of fair quality. It might be worth the experiment to try if these limestones at Bloomfield would yield hydraulic cement. I have also seen the Marcellus limestone at its outcrop between Bloomfield and Clark's mill, where it may again be taken as evidence against the presence of a thick bed of ore. A partial analyses of this limestone will be found in that part of the report relating to Madison township.

The Marcellus iron ore bed.

This is the bed from which most of the iron ore raised in the township has been taken. Its outcrop may be readily traced upon the geological map, as it coincides with the line between the Marcellus limestone and the Marcellus black shale. As will be seen at a glance its course is exceedingly irregular, and the tracing of it through the township was a task of some difficulty. The complication of the structure of Centre township will be evident to any one who carefully examines the maps and sections given with this report. Following the ridges of sand-rock across a county may seem, at first sight, a very unprofitable task, but in no other way was it possible to determine the ground in which this bed of iron ore could or could not exist.

This ore is often called in the district the limestone ore, to distinguish it from the other ores in the county. The name is not strictly true in the sense intended, and yet it is true in another. It does not lie in or on the Lewistown limestone—the great limestone of the county—but it does lie in contact with a bed of impure greenish limestone or calcareous shale which has been erroneously considered the equivalent of the Corniferous limestone of New York. This is never far from the great limestone, its proper horizon being about 50 feet above the Oriskany sandstone. Hence the upper surface of the sand-rock when it can be discovered, is an unfailing guide to the position of the ore.

The first outcrop line of the Marcellus hematite enters

Centre township from Miller, and runs immediately south of the Oriskany sandstone till it crosses the Newport-Bloomfield road about a quarter of a mile north of the summit of the ridge. It then continues west-southwest to the Old Juniata furnace works on the old road to Newport. No yield of ore has been obtained from it along the line of outcrop, so far as I am aware, east of this place. But at this point it begins to afford a rich supply, and great quantities were taken from it while the furnace was in blast. As will be seen at once by inspecting the map the field over which the ore has been proved is not extensive. It consists only of a long narrow tongue of shale land bounded by two converging ridges of the Oriskany sandstone which meet in the woods about a mile west of the Furnace road. Erosion too has destroyed a portion, the stream coming from Limestone ridge having cut its way across the narrow syncline and removed the two Oriskany ridges with the intervening black shale and ore, and other beds over a considerable space. The course of this ore-bed may be traced in the sketch-map, Plate XV, page 174, Fig. 1.

The second line of outcrop of the Marcellus ore comes in also from Oliver township as a narrow almost closed syncline shown on the map. In Oliver township this syncline is more open, in fact double in some places, and has yielded an immense quantity of ore for the supply of the Marshall furnace at Newport. (See Report on Oliver Township.) But in Centre township the greater portion of the syncline has been eroded and washed away leaving only the bottom. Consequently the iron ore so abundant a mile to the northeast is here almost absent. Numerous holes have been dug but little has been found to reward the labor. And the geological indications are that nothing will be found because the ore has been eroded. (See Page Plate XVI, Fig. 4.)

Following the beds a little farther to the west the Oriskany sandstone is cut out of the syncline altogether at the school-house, and henceforth the limestone alone remains.

The third outcrop of the Marcellus hematite comes in from Miller township, passing about 100 feet south of Pine Grove church where attempts have been made to find the

bed, without much success. Thence it runs along the north foot of Mahanoy ridge to the western boundary of the township. It has been opened in two places with some success. One of these places is on the farm of Mr. George Barnett, at Bloomfield, where the adit which has been driven along the ore-bed enters just above the level of the Little Juniata, and is carried in until the ore is reached. The ore which is brought out is what is locally called pipe ore. This name is given to it on account of its occurring in hollow masses which sometimes resemble pipes. It is the stalactitic brown hematite of the mineralogist. These so-called pipes are usually full of clay, the presence of which renders it necessary to wash the ore. Horse-power was here employed for the purpose, the water of the stream being pumped up and delivered at the upper end of a long sloping trough. The ore is thrown into the lower end of the same, and a shaft fitted with iron studs, set askew upon it, turns continuously in the trough. The shaft acting as an interrupted Archimedean screw, slowly raises the ore against the stream of water and delivers it at the upper end comparatively free from clay and ready for hauling. This is the process usually employed for washing ore throughout the district.

Work has been discontinued for some time past at this level, (1883,) the ore-bed being of small thickness, and the contiguous Marcellus limestone well developed. I have observed in Perry county that these two beds usually bear an inverse ratio to each other. Where the ore is thick the limestone is thin or absent, and *vice versa*, so that the presence of the Marcellus limestone may be considered a strong argument against the existence of the ore.

Barnett's ore bank section, New Bloomfield.

- 200' \pm 0" Marcellus black shale.
- 2' 0" Marcellus upper ore bed.
- 15' 0" Hard greenish calcareous shales with *Atrypa reticularis*, = Marcellus limestone.
- 10' 0" Marcellus shale.
- 2' 0" Soft greenish shales with *Beyrichia*.
- 4' 0" Marcellus lower ore bed, brown hematite, stalactitic and slaty—thin bed of fossil ore.
- 20' 0" Oriskany sandstone, soft and friable, pebbly.
- 13 F².

Another opening of a similar nature is found about 3 miles west of New Bloomfield, on the ground of Mr. Darius Long, by whom it is leased for a royalty of 18 cents per ton. Like the preceding, this opening lies under the southern slopes of Mahanoy ridge, and is geologically on the same horizon—the Marcellus ore bed. The ore is of similar quality, being pipe ore for the most part, and of course needs washing. The bed here also dips almost vertically, so that the labor and cost of working is rapidly increased as it is followed downwards. This is one of the great drawbacks to mining the Perry county ores. If access is obtained by a level only a small quantity can be reached, and if by a shaft, the water, in wet seasons especially, is apt to become troublesome. Moreover, every yard in depth means an increase in the cost of raising the ore. At this (Mr. Long's) bank a small steam engine has been erected, which also pumps out the water which is employed for washing it. In dry seasons, such as that of 1881, the supply is insufficient, the sump being dry by midday, but in wet seasons more than enough can be obtained. The shaft is now (December, 1881,) 67 feet deep, and the ore is followed nearly east and west from the bottom of it. The bed is from 4 to 14 feet thick, with a parting of clay dividing it into two smaller beds. This of course is separated in digging it. The yield varies according to the force employed. In December, 1881, I was informed that 100 tons a month of washed ore were brought to bank, and as about half of it is lost in washing this must mean 200 tons of crude ore. It was then worth at Newport, 9 miles off, \$3 50 a ton.

The hematite was followed almost down to drainage level and began to show signs of giving place to the blue carbonate of iron, a much less valuable ore, because it needs roasting. This and the growing cost of lifting to the surface, and of haulage to Newport, and the diminishing price given at the furnace have combined to reduce the profits below cost, and the works were suspended in the early part of 1883. The ore has also been proved on the land of Mr. Neilson, near the west line of the township.

No other attempt has been made so far as I am aware to open and work the ore along this line of outcrop.

Another small outcrop of the limestone ore occurs near the Perry furnace in the southwest corner of the township. It runs in a curve round the furnace between the Oriskany sandstone and the black shales, but is of very small extent, and so far as I am aware was never worked in the township though a small opening exists a short distance over the line in Spring township.

Another outcrop of the Marcellus ore occurs about a mile north of New Bloomfield, where in one of the long, narrow synclinal folds running southwestwardly from the old Juniata works it has been mined in the woods under cover. This outcrop may be traced on the map of the county north of Bloomfield. The works are now abandoned and have fallen in. The ore was hauled half a mile to the stream in Dorran's narrows for washing.

The outcrop at the old Juniata furnace is the last of which mention need be made. This is at the same time the oldest and most productive in the township and second to few in the county in these respects. It was worked for the furnace half a century ago and immense quantities of ore were extracted at great cost, especially in the eastern portion of the works where the cutting is about twenty-five feet deep and open. Traces of the old works may be found scattered through the woods on the west of the road nearly half a mile distant. These works were abandoned about forty years ago, when the introduction of coal and coke ruined the charcoal-iron industry and they lay idle for many years. They have, however, been reopened by driving a tunnel through the Oriskany sandstone ledge on the north side of the syncline, whereby access has been obtained to the ore beds lying within it and a considerable quantity of ore extracted and hauled to Newport by Mr. Reeder.

The position of Mr. Reeder's works and tunnel is shown in Plate XVII, page 178, Fig. 1.

The Marcellus black shale.

There are not many places in Centre township where this

rock is exposed. It is soft and consequently much disintegrated by the weather. Lying as it does with other soft beds between the two sandstones, the Oriskany and the Hamilton, it is generally covered with the wreckage that has fallen from their slopes so that its detection is difficult.

The Marcellus black shale, together with the Hamilton lower shales, is usually much excavated by atmospheric erosion and forms a deep valley lying alongside of the Hamilton sandstone ridges which it accompanies in all their zig-zagging course through the townships. An examination of the map and sections will enable any one to follow its outcrop without further explanation.

This rock consists of thin, dark or nearly black layers of shale, very smooth in most places but occasionally slightly sandy. It so closely resembles the formation in New York on the same horizon that even without fossils there would be little difficulty in identifying the two.

The best exposure of this rock in the township is in the field adjoining Barnett's rocks directly south of New Bloomfield. The beds are there nearly vertical and have yielded no fossils.

Another smaller one is in the syncline on the top of the hill between New Bloomfield and Clark's mill, where I have been told that the plow brings fragments to the surface.

A third exposure occurs at the cross-roads between Limestone ridge and Buffalo hills on Dorran's run, where in the search for ore many pieces of this rock were brought to the surface. These on examination yielded a few fossils a list of which will be given elsewhere.

A fourth exposure of these black shales occurs near the ore works of the old Juniata furnace two miles east of New Bloomfield. A double section is here made. The end of the syncline coming west from Newport narrows gives the black shale dipping both ways on both sides of the cross-road. On the south side it has been extensively excavated in the search for ore but on the north side no attempt has apparently been made to find the bed.

The Hamilton lower shale.

Lying immediately over the black Marcellus shale come the Lower Hamilton shales, softer and lighter in color. They run through the township, following very closely the line of outcrop of the Hamilton sandstone which overlies them. The latter forms the ridges the former the valley. Unable on account of its softness to resist the weather as the hard stone has done, it has been eroded by frost, sunshine, and rain, and now forms valleys alongside of the harder rocks. The northern slope of Mahanoy ridge and the southern slope of Buffalo hills are composed of the Hamilton lower shales, covered very deeply by the wreckage from the overhanging Hamilton sandstone. The slope at the western end of Dick's hill also consists of these shales rising from under the heavy sandstone. It extends in long tongues west into Iron ridge, and is gradually thrown out by the rising of the older limestone to the surface.

No other outcrop of the Hamilton lower shales exists in Centre county, and in these the exposure of bed rock is rare. In only one or two places in the gaps or passes as on Dorran's run and at the old Juniata furnace can the lower shales be studied in place.

Fossils.—These shales are exceedingly barren, frequent and careful search at all the outcrops in the township having failed to bring to light any fossils. Either life in the ocean of this age was scarce in Centre township or all traces of its existence have been destroyed.

Land.—The Lower Hamilton shales yield mostly poor land, inferior to that over the other shales of the township. Good farming and free expenditure of labor can, however, render it fairly productive and in the end profitable.

The Hamilton sandstone.

This is the most conspicuous feature in the physiography of Centre township. The Lower Helderberg limestone forms a high ridge, but most of it is under cultivation, and more of it would be tilled were it not for the numerous sinkholes on its surface. The Oriskany sandstone in many places

caps the limestone with its rugged range of pulpit rocks. But the Hamilton sandstone is massive and hard enough to stand up in bold lines along the township, and so far to resist the weather as to maintain a steep slope on one or both flanks. Consequently it forms not only the most conspicuous, but the most important feature in the physical geography of the township.

The first outcrop of the Hamilton sandstone.—The Buffalo hills are the most northerly line of outcrop of this formation. A long, straight, high wooded ridge of sandstone enters the township southwest of Mannsville and ranges E. 30° N. to the road between New Bloomfield and Newport, when, at the lower end of the narrows, it suddenly turns back upon itself and runs W. 30° S. to near the old Juniata furnace. Here turning again it resumes its former course and passes the line into Oliver township. This doubling back of the sandstone upon itself is the cause of the great length of Newport narrows. The stream—Inoculate run—has cuts its way through the sandstone at its very widest point, and zigzagging along has made its course yet longer. See Plate XVII, page 178, Figs. 2 and 3.

Probably the doubling of the sandstone formed a line of weakness where the rocks were more crumbled and broken than elsewhere. Moreover, the elevation of the ridges was less because there are in that place three instead of one as in the rest of the range. The water from Limestone ridge consequently was thrown into this channel by the latter cause, while the former rendered the destruction of the rocks more easy and rapid.

There are three other gaps or narrows through the Buffalo hills in Centre township, down which the water comes from Limestone ridge into the Little Buffalo.

The Juniata Furnace gap is about a mile west of Newport narrows. Through this the old road to Newport passed. Traces of it may be yet seen near the south end. Less narrow and picturesque than some of the other passes, it contains one of the finest tracts of hemlock spruce that can be seen in the township. The ruins of the old furnace works remain in the middle of the narrows.

Dorran's gap is a mile west of the Juniata Furnace gap. Through this a little stream of the same name flows to meet the Little Buffalo. This is the prettiest and most picturesque of all the passes in the township. The road runs alongside of the brook, and is shaded with the hemlock spruce and white pine. Ferns abound in the damp shady ground. Among these the Narrow Sword fern, *Polystichum acrostichoides*, the Margined Shield fern, *Lastrea (asplenium) marginalis*, and the Common Polypody, *Polypodium vulgare*, are the most abundant, but the prize of beauty must be awarded to the elegant and delicate Ebony Spleenwort, *Asplenium ebeneum*, which grows here in unusual rankness and abundance. The good drainage afforded by the broken Hamilton sandstone and the shade and coolness produced by the overhanging timber combine to render this gap a natural fernery.

Hentzel's Narrows is the third gap through the Buffalo range, about two miles further west. Owing to the geological structure of the ground this pass is also a long one, extending through the Oriskany sandstone and overlying Marcellus and Lower Hamilton shale, the Hamilton sandstone and part of the upper shale. Some parts of this gap are also very beautiful, but as a whole it falls short of that last mentioned. A stream flows through it, coming from the limestone land, though Limestone ridge can scarcely be said to exist at this point. It has been cut down and carried away to so great an extent that the road passes through it almost on a level. Broken pieces of the Hamilton sandstone cover the slopes to such a depth at some points that trees cannot grow, the depth of stone being too great to allow their roots to reach the earth.

Further westward three other roads cross the Buffalo hills, but only one of them passes through a gap, and this gap, owing to the inferior hardness and gentler dip of the sandstone, presents less striking features and needs less detailed description than those already mentioned.

A considerable branch of the Little Buffalo passes down the gap just noted, and is the highest of its tributaries which flows off the limestone ground. There is a fact con-

nected with this stream for mentioning which the present is the proper place.

All along its course and along the Buffalo valley may be found scattered over the ground blocks of the white chert which underlies the Oriskany sandstone and which exists nowhere in the valley. It has been carried down by the ice on this and other tributary streams from the south side of the Buffalo hills, or rather from the north slope of Limestone ridge, to its present position. Moreover it now lies 30, 40, and even 50 feet above the present bed of the Little Buffalo; showing that the Little Buffalo, at least in flood time, must then have flowed at that height above its present level; that it has cut down its channel and the valley in which it flows to a very considerable extent since these stones were deposited. We have no means at present of measuring this lapse of time in years. The flint is exceedingly hard and capable of enduring for ages, so that there is no improbability in maintaining that so great an amount of geological erosion has been accomplished during the lifetime, so to speak, of these stones.

Mahanoy ridge.

The second outcrop of the Hamilton sandstone in Centre township forms a long, straight ridge, passing half a mile south of New Bloomfield. This much resembles the Buffalo hills in structure and the description given of *them* is applicable also to Mahanoy. It is equally steep and rugged and for the most part covered with timber. Only two gaps or passes exist through the ridge in Centre township, one near New Bloomfield and the other about a mile farther east. Through the first passes the Bloomfield branch of the little Juniata, which brings down all the water from the eastern part of the township between Limestone ridge and Mahanoy. It is only a small brook and there is no obvious geological cause for its having chosen this spot for cutting through the Hamilton ridge. The softness of the Oriskany sandstone south of Bloomfield probably allowed its passage through that barrier, and a less height of the ridge may have compelled it here to cross the other. This gap pos-

sesses none of the beauty of those through the Buffalo hills, being occupied almost wholly by the road, the stream, and the mill-race.

The second gap about a mile to the eastward also gives passage to a small stream flowing from several ample springs in the valley, one on the farm of Mr. Oliver Rice and another on that of Mr. R. Moore. Its course consequently is short but it supplies power to two mills in the narrows. In physical features this gap resembles those in the north of the township but both the gaps in Mahanoy ridge are short compared with those in the Buffalo range. The geological cause of this is obvious. The Hamilton sandstone in the former stands almost vertical whereas in the latter it dips at an angle of about 30° to the north. Consequently in the former the thickness of the formation—about 600 feet—measures the breadth of the ridge and the length of the gap while in the former owing to the angle of dip these measurements are doubled. (See Plate XVII, page 178, Fig. 4.)

Both the ridges, as may be seen from the diagram, are monoclinical or one-sided, the intervening portion of the arch represented by dotted lines having been swept away.

The third outcrop of the Hamilton sandstone in Centre township is the eastern end of Crawley hill, the western part of which is in Spring township, and forms a high rough ridge parallel with Mahanoy, and distant only about half a mile. Between them runs the Little Germany fault.

The hard middle beds of the Hamilton sandstone are well exposed on the top of Crawley hill, and flagstones of fair quality are sometimes quarried here for curbing. The ridge rises abruptly from the south side of the road from New Bloomfield to Little Germany, and the valley cut in the Hamilton upper shale and Genessee becomes narrower and narrower towards the west. This ridge differs in structure from those already described, being an anticlinal or arch, as may be seen by examining the sections through the county.

A fourth outcrop of Hamilton sandstone occurs immediately south of the last, but, so far as I have been able to learn, has no distinctive name. Its most eastern point is

on the road to the Old Perry furnace near the residence of Mr. George Meck. This outcrop is produced by a small fault which brings up the sandstone of the south side of Crawley hill after it has sunk below the surface. Its extent is small and it will be found described with the other faults. See section.

The fifth outcrop of the Hamilton sandstone will be found a few hundred yards south of that last mentioned. This, which is also anticlinal, is less compressed than the two preceding, and as it continues to the west-southwest it gradually opens and discloses by erosion the Lower Hamilton and Marcellus shales, and farther west the Oriskany sandstone and Lewistown limestone. It thus forms two nearly parallel monoclinal ridges meeting at an apex at the eastern end. These are known in the district as the Furnace hills, north and south, and afford beautiful views of mountain and woodland scenery to the traveler driving or walking along what is well named the Tape-worm road. On a smaller scale the view resembles that in the Cove, but there the geological structure is synclinal while here it is anticlinal. The two however produce similar results on the landscape.

The Sixth outcrop of the Hamilton sandstone and the most southerly in Centre township is in the range of Dick's hill. This, the highest and boldest ridge in the township, is about four miles in length, reaching from a point one mile and a half west of Losh's Run station to the old road from New Bloomfield to Carlisle. This, like Mahanoy ridge and the Buffalo hills, is monoclinal, the northern half of the anticline, of which it was once a part, being concealed by the great Perry county faults, an account of which will be found in another chapter.

Dick's hill is a rough wooded ridge steeper on the north-western than on the southeastern slopes, and rising near the western end to an altitude of about 300 feet above New Bloomfield. Only one gap exists through it, the picturesque Montebello narrows, through which passes the Little Juniata. After flowing nearly parallel to the range along its whole length and gradually approaching it, this stream

turns suddenly southward and cuts obliquely through the various strata from the Lewistown limestone to the Hamilton Upper shale, making one of the longest and most beautiful passes in the county, and one of the habitats of the Deer's Tongue laurel (*Rhododendron maximum*.)

The zigzag form of Montebello narrows is probably a result of the exposure of some shale beds lying in the sandstone where the stream flowed across the ridge as it rose. After crossing the first belt of hard stone it worked its way for some distance along the softer bed, and then meeting some obstacle turned to the southward at a place where the second belt of stone was low and gradually cut a way through it. A similar tendency to excavate a valley in the middle of the Hamilton sandstone may be seen in other places in the county where the dip is not great, as for example at Rattlesnake hill and Hentzel's narrows.

The western end of Dick's hill is formed by a zigzag in the stratum of sandstone which bends back upon itself to the eastward and passes out of the township. Its further course will be found in the account of Wheatfield and Carroll townships, where it may be traced on the geological maps.

Though it has not been possible to obtain a complete section of the Hamilton sandstone in Centre township, yet the following partial section indicates the relative position of some of the fossiliferous beds :

Top. Fine green sandstone, even bedded, containing numerous fossils, especially *Homalonatus Dekayi*, *Tropidoleptus carinatus*.

Space concealed.

Very hard ferruginous sandstone, with *Tropidoleptus carinatus*.

Space concealed.

Dark sandstone with abundant fossils. *Tentaculites attenuatus*.

Space concealed.

Soft yellowish sandstone with casts of *Spirifera formosa*.

This is *the fossil bed* of the sandstone, and the bed that has yielded in the south of the county, *Rensselaeria*.

Space concealed.

Coarse sandstone with indistinct fossils.

Space concealed.

Base. Fine green sandstone with a large *Murchisonia*.

The Hamilton fossil ore bed.

This ore bed, an account of which has already been given, follows in its outcrop the line between the Hamilton sandstone and upper shale, and may be traced by means of that line upon the map. It cannot be called a valuable ore bed, yielding, as it does, not more than 25-35 per cent. of metallic iron. Yet were a market readily accessible, or the price of iron higher, there are several places in the township where it might be profitably mined for mixing with the richer kinds of ore. During and even after the war, when prices ran high, this ore was taken out in several places, but these have been gradually abandoned and there is no place in the township where it is now mined.

The Hamilton fossil ore bed enters the township from Oliver at the northeast, and zigzagging with the sandstone crosses the road from Newport to New Bloomfield near the bridge over Inoculate run at the north end of the narrows. Here its presence is plainly indicated by the fossil evidence, but the ore bed itself is thin or absent. Thence it ranges W. S. W. along the N. N. W. front of the Buffalo hills, where it has been exposed at several places, on Mr. Toomey's land for instance at the north end of Dorran's narrows. It lies for the most part, perhaps altogether, in the woods above the cultivated land and about 300 to 500 feet south of the outcrop of the richly fossiliferous Fenestella shales which may be traced all along the valley at intervals. It has not been opened at any other place along this line, except on the Little Buffalo at the junction of the roads near Pine Grove school-house, where a drift has been run in along the course of the bed and some tons of ore extracted. Nothing, however, has been done here for years.

The second line of the Hamilton fossil ore in Centre township comes in from the east north of another Pine Grove school in *Miller township*; it runs along the south side of Mahanoy ridge. Little has been done to prove it along this line. An attempt was made by Mr. Reeder some years ago at the south end of the gap near the fulling mill, but apparently the results were not promising. All the indica-

tions of the bed were present—the Paracyclas shale which lies close upon it being reached—but the bed itself seems to have been thin and worthless. The opening is now closed so that nothing can be learned by inspection except from the waste material thrown out. This, however, amply proves that the drift was made in the right place.

Signs of the same bed occur in the gap south of Bloomfield and there is no doubt that the ore bed skirts the woods on the south side of the ridge. But it is deeply covered with wreckage from the sandstone above, and judging from the evidence in the two places mentioned it is thin and not worth exploring. Yet it is only fair to observe that the same bed has yielded abundance of ore outside the line—as at G. Peterman's and P. Cook's in Miller township.

The same bed must exist around each of the anticlinal ridges described under the Hamilton sandstone, viz: Crawley hill and Furnace hills. It must skirt the north and south flanks of Crawley hill and run round the outside of the eroded Perry furnace anticline. In none of these, however, has any attempt been made to work it or even to prove it, except about half a mile north of the furnace where it was found of fair quality. Nor is it at all probable that such attempts if made would yield any other results than an expenditure of time and labor and a gain of the knowledge that the ore is of little value.

The Hamilton upper shale.

These shales, about 250 feet thick and overlying the Hamilton fossil ore, crop out in several places in the township. They are as usual nearly barren of fossils except their upper and lower layers, which yield them in profusion at almost every exposure. Locally these shales are naturally divided into four parts, as shown in the general report on the county:

Fenestella shale,	10 feet.
Tropidoleptus shale,	10 "
Barren green shale,	200± "
Paracyclas shale,	2 "

The richest exposure of the fossiliferous beds of the Up-

per Hamilton shales with which I have met is near New Bloomfield, on the south side of Mahanoy ridge, and a few hundred feet southeast from the mill owned by Mr. G. Barnett. Here on the roadside the bed crops out in the bank and contains several species of *Fenestella*, and it may be followed up the slope towards the ridge and exposed in many places. The shale is so near the surface that cultivation of the ground has been abandoned, and the fossil harvest may be easily reaped. For the most part the bed consists here of soft green shale, sometimes splitting with ease, but often tough. Many parts of it are full of fossils, and they are usually either bright rusty red or black from the presence of iron. This renders them very conspicuous, and their details are easily seen. In this place the beds are about 20 feet thick, and stand almost vertical with a slight overthrown dip of about 92° to the north. It is difficult to establish distinct horizons in this thickness, but the upper portions are crowded with *Fenestella*, often very beautifully preserved, but soft and fragile and belonging to several species. Near the middle it is characterized by abundance of *Vitulina pustulosa*, Hall, and in the lower layers which are more sandy by *Tropidoleptus carinatus*, Hall.

The Hamilton upper shales to Fenestella bed.

Very smooth, fine, dark shales, black when damp.

Greenish, soft, shaly bed with *Styliola fissurella*.

Thin, soft, rusty bed with *Fenestella*.

Soft, sandy beds much marked with bright red oxide of iron, and containing Brachiopods, Crinoids, Trilobites, &c.

Soft, shaly beds with few fossils.

Greenish, sandy shales.

Hamilton sandstone of Mahanoy ridge.

The *Fenestella* shale is also well exposed on the land of Mr. Toomey, senior, on Little Buffalo creek, and the whole thickness of the upper shale can be traced down to the sandstone. The dip here is about 30° N. N. W. From this point the fossiliferous beds may be followed without much

difficulty up the valley to the western line of the township.

Numerous other exposures of these shales occur in the township. For instance, southwest of Bloomfield, along the road to Little Germany, again on the branch road to Perry furnace, on the land of Mr. George McKee and Mr. S. Brown, and Mr. William Brunner, in the field adjoining whose brickyard they were exposed in digging some ditches, and showed the fossils very much crushed and distorted.

The Genessee shale.

This shale makes no conspicuous displays, and being destitute of fossils, can only be recognized by its position. Its dark thin layers can be seen along the road on the south side of Mahanoy ridge, but they crop out nowhere else.

The Portage shale.

Though these beds should occur in several places in the valley between Mahanoy ridge, and Dick's hill, and Iron ridge, yet I have not recognized them anywhere except near the house of Mr. S. Brown, where they crop out at the roadside and contain their characteristic fossils, details concerning which may be found in the proceedings of the American Philosophical Society for 1883, and will be given in the volume on the palæontology.

The Chemung group.

Rocks of the Chemung group occupy all the middle of the valley south of Mahanoy ridge and extend to the foot of Iron ridge and Dick's hill where they are cut off by the Perry county fault. For the most part they dip steeply to the south but the extension of the Perry furnace anticline along the valley reduces and reverses the dip so that no measurements minutely accurate can be made of their thickness. They are fossiliferous in many places, but there are few good exposures and the surface shows the usual rounded hills that mark the Chemung areas in the county. The passage from the Portage to the Chemung is well shown at

the exposure of the former near the house of Mr. S. Brown, where the smooth, thin shales of the lower are gradually supplanted by the more sandy beds of the upper group containing their characteristic thin, squarely fracturing sandstone beds.

Brick-clay and sand.

Clay suitable for making bricks is found in several places in the township. A bed exists close by New Bloomfield on the ground of Mr. Barnett where many thousand bricks have been made and burnt. Their quality is fair but not excellent. They shrink very much in the fire when burnt at a high heat and are said to bend. This brick-field and another of similar quality belonging to Mr. William Brunner, about two miles southwest, supply most of the bricks employed in the town. They are sold on the ground at prices varying, according to quality, from \$5 50 to \$7 00 a thousand.

These clay beds are all composed of the material washed down from the neighboring hills. The clay is white with a faint tint of blue. It contains a considerable quantity of iron, as is shown by the color of the bricks.

The beds are not thick, the workable depth being only about two feet. Below that the clay contains fragments of shale which render it unsuitable for the purposes of the brickmaker. It occurs where the valleys are a little wider and flatter than usual but not in the narrower and deeper ones, and is evidently the product of the flooding of swampy ground during many years. A similar white marl is often found in several places in digging ditches through low-lying lands, so that brick-making material is abundant.

Sand for building purposes is obtained from two sources in Centre township. That which is used in New Bloomfield and to the south is found at the outcrop of the Oriskany sandstone, south of the town. Differing here from its usual condition this formation, instead of being hard and resistant, is soft and friable, so that it can be dug out with a spade. At the exposure on Mr. Barnett's land it is pebbly, the pebbles being fine and white and having the appearance

of small white beans. These are screened out and used for rough-casting the plastered houses, while the sand that passes through the screen is used for making mortar, &c.

At the next exposure, on the land of the Hon. William Grier, the Oriskany sandstone consists of pure white or yellow sand, almost free in some spots from pebbles, in others containing a great many. Though the Oriskany abounds in fossils where the beds are hard, yet they seem to be altogether absent where these beds are soft and sandy.

It is also worthy of notice that only in this low ridge of Oriskany lying interruptedly along the north foot of Mahanoy ridge does it present this soft friable aspect in Centre township. Nor do all parts of this ridge present it equally. At a very few yards' distance to the east it consists as usual of a chain of rugged pulpit rocks of considerable hardness. Farther west it crops out as a similar rugged chain, but at Mr. Long's ore works the soft sand again appears, and much of it has been excavated in the search for iron. On the northwest of the town, in some spots, soft sandstones occur, easily crumbling down under the hammer, but not capable of being dug out, as at the places just mentioned.

In the north of the township sand is obtained from a bed several feet deep lying on the very top of the Buffalo hills about midway between Dorran's and Hentzel's narrows. It is not easy to account for its formation. It can hardly be the result of water-action. The place of its occurrence is on the low part of the ridge where a foot-path crosses from the Buffalo valley. It has been dug out to the depth of about two feet and apparently extends much deeper. It is mixed with angular pieces of the Hamilton sandstone but few very small fragments. This sandstone is not subject, like the Oriskany, to be soft in places nor is it liable to rapid disintegration under the action of the atmosphere. The great accumulation of sand on this rock at so high a level in the present configuration of the surface is therefore an apparent anomaly.

The Little Germany fault.

This fault, of which an account will be found in the report on Spring township, enters Centre at the southwest just where it cuts through the topmost beds of the Hamilton sandstone. The lateral displacement here is about a mile, and through the gap thus left in the eastern rampart of Little Germany, passes the road to New Bloomfield. At this point the Lower Hamilton shales of the eroded Crawley anticline abut against the Genessee or probably against the Portage shales of the south slope of Mahanoy ridge. Consequently the throw of the fault is here at its maximum. We may form an approximation to its extent from the following figures which represent the thickness of the several groups as nearly as I have been able to determine them :

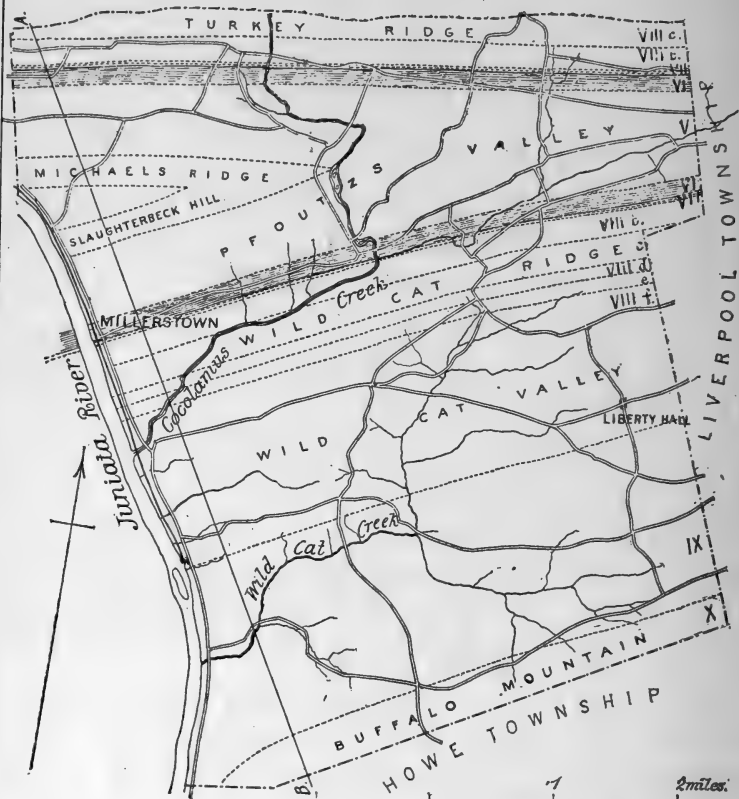
Portage, part,	50 feet.
Genessee,	200 "
Hamilton upper shale,	300 "
Hamilton sandstone,	600 "
Hamilton lower shale, part,	100 "
<hr/>	
Total throw,	1250 "

This is little, compared with the throw of the Perry county fault a mile further south, but is yet sufficient to produce important changes in the geology of the county.

From this point the fault continues northeastward and about a mile from the township line the disjointed edge of the Hamilton sandstone is seen rising on the south of the road. Soon afterwards the Hamilton upper shales showing the *Tropidoleptus* bed appear in the road, and at the fork to Perry furnace the throw of the fault has become quite insignificant. It may however be traced for nearly half a mile farther. The *Tropidoleptus* shale crops out at the residence of Mr. Wm. Brunner and then follow, descending, the Genessee shales, thus indicating very closely the place of the fault. It is here indicated by a depression which, enlarging to the southwest, becomes the valley along which we have, in imagination, been traveling from Little Germany.

The only conspicuous evidence of the fault east of this point is the repetition of the Hamilton upper shale without inversion and the presence of the Genessee between the two outcrops. The lower outcrop is at the fork of the road near Mr. Sanderson's, and the higher at Mr. Wm. Brunner's. In both cases the lower beds lie to the north. A plan of the fault may be found in the account of Spring township.

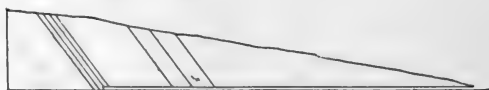
Greenwood township.



Section through Pfoutz's valley from W. to E.



Section in Slaughterbeck hill through ore tunnel.



4. Greenwood township.

This township lies on the north line of the county and east of the Juniata river. It is bounded on the north by Turkey ridge, on the west for the most part by the Juniata, on the south by Buffalo mountain, and on the east by an imaginary line which parts it from Liverpool. It contains about 25 square miles. It is divided naturally into two wide open valleys by the high and rugged Wild Cat ridge, across which there is only one good road near the middle of the township.

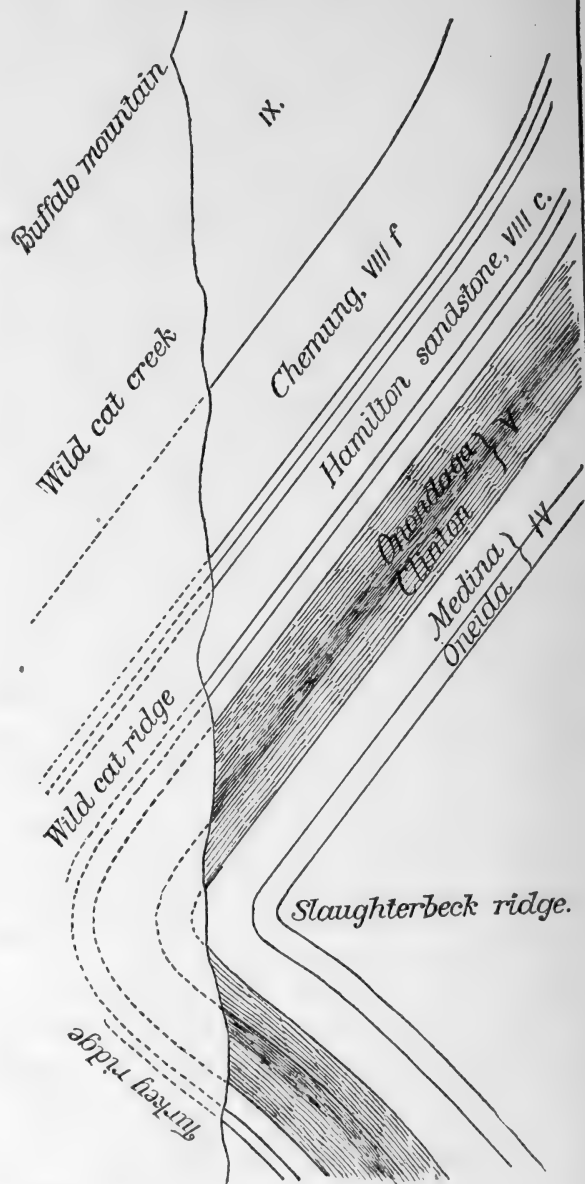
Pfoutz's valley lies on the soft beds of the Clinton and Onondaga shales and narrows to the eastward, where it extends into Liverpool township.

It has no drainage system of its own. All its water-courses that are large enough to require notice fall into Cocalamus creek which enters the valley from Juniata county through a gap in Turkey ridge, and leaves it to reach the Juniata in Wild Cat valley.

The eastern branch of the creek which drains the upper end of the valley comes down from the high land on which runs the line between Greenwood and Liverpool townships and flows along the northern base of Wild Cat ridge until it meets the larger branch coming down from Juniata county, and both united skirt the range until they find a way through it near Millerstown. Of this gap further mention is made later.

The soil of Pfoutz's valley is good, being for the most part composed of the same shale that is so abundant in the west of the county. Pfoutz's valley also contains part of the most valuable stores of iron-ore now worked in Perry county. Of good quality, yielding a high percentage of iron lying in soft material, and at a convenient dip, these beds of fossil ore can be profitably worked when no other vein

Section line AB across Greenwood township.



in the county will pay. The beds are unfortunately not thick, seldom exceeding twelve inches, but the advantages above-mentioned more than counterbalance this defect. (For further details concerning the ore see page 217.)

Slaughterbeck hill, sometimes called *Michael's ridge*, is a conspicuous object from every part of Pfoutz's valley. It blocks the entrance from the west, rising above every other range in the township. It is really a fragment of the great Tuscarora anticlinal which has been cut off by the Juniata river from the main body and constitutes an outlier. In truth the whole of the valley is a continuation eastward of the anticlinal ridge of Tuscarora, eroded by long ages of frost, rain, and sunshine. The beds dip eastward at a gentle slope, disappearing one after another under newer overlying ones. The structure of the valley may be easily understood from the map and section on Plate XVIII.

It will be seen at once that the sandstone of the Tuscarora range passes down underneath the lower green shales of the Clinton group, these beneath the Iron sandstone and this beneath the upper green shale, fossil ore, and sandrock. Over all these lie the Onondaga shale, the Lower Helderberg limestone, and the Hamilton group of Wild Cat ridge.

Wild Cat valley composes the southern part of Greenwood township. It is broad and open, intersected with ridges running lengthwise, some of which are steep and wooded, and others gently sloping and cultivated. Through this valley Wild Cat creek flows into the Juniata, carrying almost all the water that runs off its surface. Its head springs are in Wild Cat ridge and Buffalo mountain and on the water-shed between the two rivers, which here lies wholly in Greenwood township.

The northern portion of this valley lies for the most part on the green shales and shalestones of the Chemung, yielding as usual a soil of little fertility. Its southern part, on the red sandstone and shale of the Catskill, is of much better quality for farming, and as in other parts of the county the Catskill soil compares favorably with the geologically older red shale land of Pfoutz's valley and the west of the county.

Buffalo mountain is thickly wooded with chiefly small timber, and is traversed by only one road leading through a gap into Howe township. (See Howe and Liverpool township, on pp. 223, 241.)

The Medina sandstone, No. IV, and the Clinton lower shale, No. V.

The Medina sandstone is only seen in this township near its northwestern corner where the point of the great Tuscarora anticline is cut off by the Juniata river. It forms the axis of Slaughterbeck hill or Michael's ridge, its beds dipping north and south from the axis. This point of high land is surrounded on three sides by a trench caused by the removal of the soft Lower Clinton shales which formerly filled it. The sandstone which farther west forms the high, straight crest of Tuscarora mountain sinks to the eastward so rapidly that on the eastern line of the township it is nearly a thousand feet below the surface.

The point alluded to above—*Slaughterbeck hill*—forms a striking object from the east end of the township. Standing out boldly in the midst of the valley it resembles some huge fortified camp surrounded by a deep fosse cut out of the Clinton lower shale and again by a ring-wall composed of the hard beds of the Iron sandstone. From the whole of Pfoutz's valley this natural fortress can be seen flanked to north and south by the long ranges of Turkey ridge and Wild Cat ridge.

The Clinton Iron sandstone.

The Iron sandstone is apparently only a few feet thick in this township yet its hard, thin, red layers are capable of forming a distinct ridge or minor crest around Slaughterbeck hill which may be traced from the Juniata river eastward for about three miles where it turns and runs back to the river a little north of Millerstown. With its disappearance eastward the general level of the country sinks and both the Iron sandstone and ore beds pass down underground to the eastward and on the township line are already far below the surface.

The eastern point of the hard Iron sandstone compels Cocalamus creek to make a long curve before assuming its proper course. It crosses Pfoutz's valley just at the end of the Iron sandstone outcrop.

The Clinton fossil ore.

The outcrop of this important group of rocks enters Greenwood township from Juniata county about two miles north of Millerstown, and ranging east to or perhaps across Cocalamus creek turns and passes west southwest to the Juniata river a few hundred yards north of Millerstown. Few natural shows of it occur. The beds are chiefly soft and weather down easily ; but the place of the ore is indicated by harder ridges which sometimes form terraces along the hillside.

These beds of fossil ore extend across the whole township below the surface under the red shale, but are mined only where their outcrop occurs on the hillside ; and near the river where they have been softened by water action and lie near to the canal and railway.

Many thousand tons of this soft fossil ore have been sent from Millerstown during the past 15 years, chiefly to Reading, Harrisburg, and Dry Valley, near Northumberland.

Only the uppermost bed, the Sand-vein ore bed, is worked on this side of the river. This is about a foot in thickness.

The other beds may be readily found on the hillsides. In many places they have been dug into at their outcrops, and from some a considerable quantity of ore has been taken.

The details of the section in Fig. 3, p. 212, Plate XVIII, were given me by Robert Cochran, Esq., of Millerstown, who works the Sand-vein ore bed at this place. No attempt has been made to drive further into the hill in quest of the deeper beds. Their probable position may be learned from the account given of the works of Mr. Rounsley on the other side of the river, in Tuscarora township.

The places where the greatest quantity of ore has been mined are at the workings under the management of Mr.

Robert Cochran, about a mile northeast of Millerstown, and those of Mr. S. Hoffman, about two miles further to the northeast, where the ore beds flatten down and dip more to the east before disappearing under the overlying Lower Helderberg limestone which here laps round the end of the hill.

The fossil ore beds return westward to the north of Slaughterbeck hill, but I have not been able to learn that any ore has been taken out there or any attempt made to prove the beds. They are reported to be of inferior quality.

The Lower Helderberg (Lewistown) limestone. No. VI.

Few exposures of this limestone occur along its southern outcrop in the western part of the township. It occupies for the most part the low land along the course of Cocalamus creek. It is, however, well exposed at the great bend where the stream strikes against Wild Cat ridge and is diverted to the west. Here it consists of solid heavy bituminous limestone, and some of its fossils, for example *Sp. modesta* and *Rh. formosa*, may be obtained. Its whole thickness near Millerstown is about 300 feet, but its various divisions can with difficulty be made out. At the bend in the creek before alluded to the chert beds are well shown. These beds seldom appear, being almost always disintegrated by the action of the weather.

The Oriskany sandstone No. VII.

Near Millerstown the Oriskany sandstone is exceedingly thin and makes none of those conspicuous ranges of pulpit rocks which mark its outcrop in the middle of the county. Its two lines of outcrop are drawn where the sandstone should be, rather than where it can be seen, for it rarely happens that even a fragment of it can be found except in the western part of the township, where I have picked up a few small pieces among the wreckage of the flint ridges which is there very abundant. So far as I have been able to see the Oriskany seems to thin out in the east of the township.

The Marcellus group.

These rocks, so far as I have observed, have no good ex-

posure here. The Marcellus black shale may occasionally be seen on the northern slope of Wild Cat ridge, but its outcrop is usually buried beneath the wreckage from the heavy Hamilton sandstone above it.

"Along Turkey ridge, (north side of Pfoutz's valley,) where the surface is higher than along Wild Cat ridge, the surface ore indicates the presence of the bed below, but it has been opened at very few points, and mined only at two. At Isaac Troutman's, $6\frac{1}{2}$ miles northeast of Millerstown, in one season's work for Maria furnace, 300 or 400 tons were taken from an open cut. The bed varies from 1 to 3 feet."

"On Michael Hull's land, on the Turkey Valley road, 4 miles northeast of Millerstown an open cut produced in one season a few hundred tons for Maria furnace. The bed was reported one to two feet thick."

The Hamilton group.

Two lines of outcrop of the Hamilton rocks cross this township. The northern runs along the county line from east to west and its hard sandstone forms the crest of Turkey ridge. The southern line comes in from Liverpool township forming Wild Cat ridge, and acts as a barrier to Cocalamus creek, compelling it to flow southwestward to join the Juniata. Near its mouth the creek has cut into the Hamilton strata of the ridge, beginning probably when it and the Juniata flowed at a much higher level. Its mouth is now on the south side of the ridge. There can be little or no doubt that it once met the larger stream close to the place where Millerstown now stands. It looks as if the range turned slightly to the southwest on approaching the Juniata, at the same time declining in height. But in reality Cocalamus has cut farther and farther southward and has carried away the whole mass of material which once occupied the triangular space north of its mouth, and faced Raccoon ridge on the right bank of the river.

The gradual change in the nature of the Hamilton sandstone as it is traced from the west of Greenwood township to the east deserves notice. Hard and solid near the Juniata river it becomes softer and more shaly as its outcrop ap-

proaches the line of Liverpool township, and the ridge is consequently less steep and rugged ;* this change is however more marked after crossing the line, and further notice of it may be taken in the account of Liverpool township.

The Genessee, Portage, and Chemung.

A single broad outcrop of these olive green shales crosses the township near the middle, forming a district of rounded, rather steep ridges and hills often wooded, but commonly cleared and cultivated. The land on these yellowish green and olive beds is, as usual, very poor.

The Chemung and Catskill, (VIII and IX.)

A broad belt of these rocks underlies much of the southern part of Greenwood township, from the Juniata river northeastward, making red ground. More than half of Wild Cat valley consists of this kind of land. It forms a rolling surface where the hills are not too steep for easy farming, and the ground is much more productive than on the light colored soils in the northern part of the valley.

This belt of the old red sandstone skirts Buffalo mountain on the north, its edge running nearly parallel to the road. It dips steeply to the S. S. E., diving under the sandstone of the mountain and reappearing to the south of Berry's mountain in Howe and Buffalo townships.

At the base of the Catskill group the Kingsmill white sandstone which forms so prominent and interesting a feature in the geology of Wheatfield township may be traced less distinctly in Greenwood. It is the same white or yellowish material, but not so purely siliceous. The clay it contains gives it greater toughness, and the scarcity of fossils makes its presence less easy to demonstrate, but there can be no doubt of the identity of the two beds. The only place in Greenwood township at which I have been able to obtain its fossils is on the road leading north from the gap and on the top of the ridge north of Wild Cat creek. This ridge is apparently formed by the Kingsmill sandstone, and numerous fragments lie on the surface.

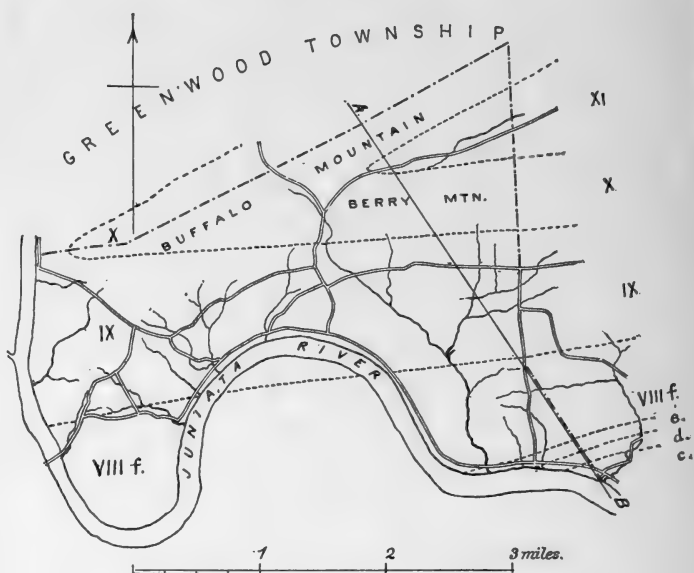
The Pocono sandstone, No. X.

This is the highest stratum occurring in Greenwood township and with it the geological history ends. It constitutes the axis of Buffalo mountain and its beds dipping steeply to the S. S. E. meet at the eastern end of the township the N. N. W. dipping beds of Berry's mountain, and both rise together into the high knob known as Buffalo mountain at Newport. Owing to the great hardness of this stone it has resisted the weather which has destroyed and carried away so vast a mass of the softer rocks and, as may be seen by inspecting the section of the township given herewith, has also removed no inconsiderable quantity of the resistant sandstone.

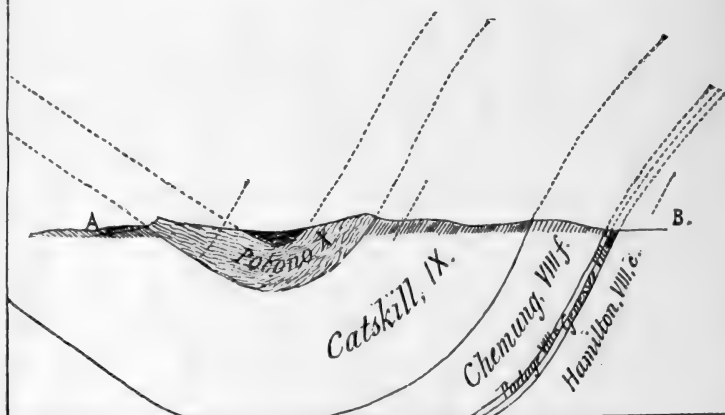
This sandstone is of the same nature and age as that composing the Cove mountain in the southeast of the county, and for further details concerning it the reader is referred to the account of Buffalo and Penn townships.

The thickness of this sandstone, as nearly as can be determined, is about 2000 feet.

Howe township.



Section along the line AB on map.



5. Howe township.

Howe is one of the smallest of the townships of Perry county, containing less than ten square miles of surface. It is also very irregular in shape being deeply cut into by the great double bend of the Juniata, which, thrown back by the Buffalo hills, returns northward and is again reflected by the high ground at the foot of Berry mountain, where it returns southward and finds a passage through the Buffalo hill barrier at Baileysburg.

To the observer of geological processes this part of the river affords some fine examples of the way in which the Juniata has been made what and where it now is. Every river and stream in turning a corner cuts away, as is well known, the side against which it strikes because the current is there strongest. At the same time on the opposite or concave side of the river, owing to the retardation of its flow, it drops its sediment.

Thus the Juniata in Howe township has gradually cut its way southward at the first bend, and northward at the second, both of which points are faced on the convex side by cliffs, and backed on the concave side by low alluvial land gradually rising from the water's edge.

The Hamilton group.

Not much notice of the Hamilton group is required here, inasmuch as its outcrop only enters the township at its southeastern corner, leaving it again almost immediately and passing under the Juniata. The Hamilton sandstone forming the most northern of the three ridges of Half Falls mountain, scarcely can be said to exist in Howe township, but the Upper Hamilton shale must exist along a short range near the old Tavern, though I have not found any exposure of it; nor have I been able to learn that any trace of the Hamilton Fossil ore bed has been seen on its proper line of outcrop.

The Genessee, Portage, and Chemung.

The southern portion of Howe township is composed, with the small exception already noted, of the rocks of this group cleft into two portions by the great double bend of the Juniata. The first portion projects southward and is nearly surrounded by the river. The second portion lies on the east side of the river. The hard sandy shales opposite Newport are only a continuation of those in Middle ridge. These same beds are continued again in Middle Bucks valley into Buffalo township. They dip uniformly to the N. by W.

In this township and crossing into Oliver occurs a calcareous bed of unusual thickness. It is only exposed so far as I am aware opposite the furnace at Newport and a mile east from this point in the river bank. Apparently it is a lenticular mass composed in great part of fossil shells, or rather casts, and extending over no great distance. Its composition, as may be seen from the following analyses by Mr. McCreath, varies much :

Carbonate of lime,	60.214	49.178	33.482
Carbonate of magnesia,	1.664	1.816	1.967
Oxide of iron and alumina,	5.384	5.761	8.298
Phosphorus, . . . . .	.068	.052	.034
Siliceous matter,	31.520	41.940	53.810

It is worthy of remark, though properly belonging to Oliver township, that this bed of limestone just mentioned seems to be the chief water-bearing stratum at Newport for the southern part of the town. As a consequence the water yielded by the wells is so hard as to be unfit for use in washing. This bed, therefore, has a very important bearing on the water supply of the town.

It may be further observed that in measuring the thickness of the different formations in Perry county, this limestone band just described has been assumed as a base to the Chemung. It is scarcely necessary to add that, being a mere lenticular bed, it has no such value, and all measurements founded on the assumption are untrustworthy. Instead of being the base of the Chemung it lies high up in that group. It is crowded with Chemung fossils, especially

Strophodonta demissa, in bad condition and chiefly as casts. Moreover, the Chemung fauna runs down below this bed for many hundred feet.

. *Section of Newport beds opposite the saw mill.*

About 300 yards below the bridge at Newport is a series of beds of sandy clay-stones, green and yellow. Dip 60° N.

In a small gully opposite the saw mill is exposed a number of different beds. The uppermost shales contain a few *Lamellibranch* shells. Then follow Yellow, soft, crumbling shales stained with bright red spots and blotches of oxide of iron.

Solid sandy clay-stones with abundant fragmentary vegetable remains extending through a considerable thickness of rock.

Reddish soft sandy shale at base.

Space concealed, about	40 feet.
Red sandy shales containing <i>Spirifera mesocostalis</i> , . .	200 "
Alternating red and green flagstones containing <i>Productella hirsuta</i> ,	200 "
Brown sandstones with green beds,	100 "
Solid green and brown claystones very sandy with shale partings,	50 "
Limestone bed, argillaceous, containing casts of encrinites and <i>Strophodonta demissa</i> , Hall,	3 "
(Strophodonta bed.)	

The Chemung-Catskill and Catskill.

These rocks form a long broad belt through the midst of Howe township, as may be seen on the map. They appear first a few hundred yards north of Newport bridge on the two roads to Millerstown and continue to their junction two miles north of the bridge. Their eastward extension forms a fine open tract of rolling land of good quality mostly under cultivation.

Middle Bucks Valley ridge, a continuation, geologically considered, of middle ridge in Centre township, is composed in great part of the rocks of this group. This ridge ranges across the township and then enters Buffalo to which the greater part of it belongs.

These Catskill rocks dip northward under the Berry mountain reappearing to the north of Buffalo mountain in Wild Cat Valley, Greenwood township.

The Pocono sandstone, No. X.

Howe township contains the angle made by the meeting of the two long lines of outcrop of the Pocono sandstone, which enter Perry county at Liverpool and Mount Patrick respectively. These two lines of outcrop diverging further after they leave the county eastward form the outer walls of the Lykens Valley coal field or Wiconisco basin, the northern fork of the Great Pottsville anthracite field.

This hard and massive sandstone, the same as that^e which surrounds Allen's cove in the south of the county, forms everywhere by its outcrop rough bold mountain ranges throughout eastern Pennsylvania, encircling all the coal basins, and compelling the rivers to cut for themselves gaps. It contains in itself evidence of coal on a small scale, but lies too low, geologically speaking, to yield any profitable seams.

There are few places where it is possible to measure with any approach to accuracy the thickness of this sandstone, but along the Susquehanna river it has been determined to be 1950 feet. The Pocono sandstone mountains carry a very high and even crest. The two ridges converging in Howe township opposite Newport are examples of this fact. Both run, with one exception, from the Susquehanna to the Juniata without a gap. No roads pass over them and they consequently form complete barriers between the inhabitants on their two sides.

The one exception alluded to above occurs near the western end of the ridge. Very near or at the place where the two ranges meet the mountain has been cut completely down, so that a road passes through without any steep ascent.

It is not easy to assign a cause for this remarkable pass. It is not a narrow dark shady gap like most of those in the county, but is wide and open. Nor is there, at present, any water flowing through it. A small stream rises about the middle of the opening and flows south; scarcely any water flows north; nor does any come from the valley included between the ridges. All the drainage of the inner slopes

of the red shale cove reaches the Susquehanna by Hunter's run.

If the Juniata, when flowing at a much higher level, cut across the point of Buffalo mountain, as six miles to the northward it has cut across the end of Tuscarora mountain, it would have made such a gap as actually exists.

Allusion was made above to the presence of a promise of *coal* in this mountain. In the gap and near its southern end are traces of an attempt made some years ago to open a coal mine. No success attended the effort nor have I been able to see any specimen except what weathered fragments can be found at the bank. There are many who yet believe that these mountains will one day yield coal, but all such faith is baseless and the expectations founded on it are futile. No workable coal exists in the mountain in Howe township, and those who are inclined to deem this a rash and positive assertion without proof must be referred for the facts on which it is based to the report on the Cove mountain sandstone in Penn township and the chapter on "The Coals of Perry county."

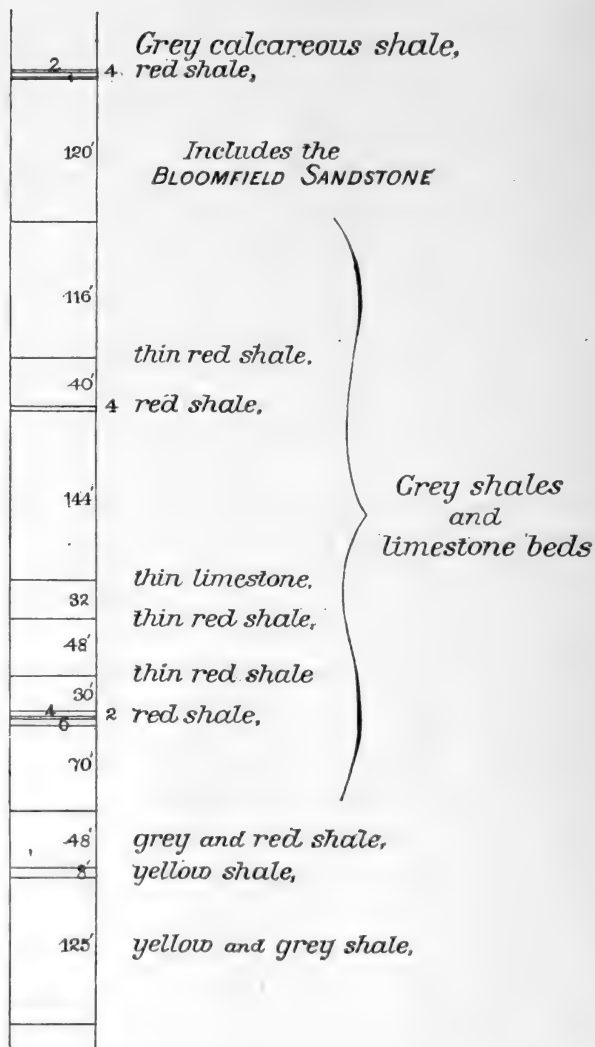
The Mauch Chunk red shale No. XI.

This formation occupies a small area in the northeast of the township between the mountains at the head of the northern cove. It is the youngest geological formation in the county, and is only found in the three townships, Howe, Buffalo and Penn.

Onondaga shale.

Section on Valley road

between N. Bloomfield and Enslows mill.



6. Jackson township.

Jackson township like Toboyne and Madison extends across the whole county from West Tuscarora mountain on the northwest to the Blue mountain on the southeast, and is bounded on the east and west by two straight lines drawn from mountain to mountain.

It is eight miles long by four miles wide and being nearly rectangular measures about 32 square miles.

It is divided into three parts by natural barriers which isolate these parts almost completely from one another.

1. *Horse valley* is enclosed between West Tuscarora and Conecocheague mountains over neither of which is there any road in the township. This portion is almost entirely covered with forest and its eastern end is one of the wildest parts of Perry county, where a bear may still be occasionally met with.

2. The second part is the wide, comparatively open valley in the middle of the township consisting for the most part of cleared and cultivated land, though towards the south are several low ridges covered with wood, the foot-hills of Bower mountain.

3. The third part is a long, narrow valley contained between the Blue and Bower mountains, accessible by a road over the latter nearly three miles long and requiring at least two hours for passage. The highest point of this road is 1350 feet above Landisburg, 950 feet above the valley at its foot, and nearly 2000 feet above the sea.

Shaeffer's valley as it is called in its lower, or *Henry valley* in its upper part, is a long, narrow strip the mountain-walls of which meet in the middle. It is sparsely settled and for the most part covered with wood. *Ahl's tannery* occupies the middle of it, from which a road passes over the Blue mountain into the lower part of Doubling hollow.

All the water of the township reaches Sherman's creek. *Brown's run* entering from Toboyne comes in at Mount Pleasant. *Houston's run*, draining the valley between Chestnut hills and Bower mountain, passes through a gap in the former called *Beavertown narrows* and reaches Sherman's creek at Enslow's mill. *Laurel run* or *Murray run* drains the narrow valley at the south of the township and passes into Madison.

The chief ridges guiding the course of the streams are *Conecocheague mountain*, a monoclinal southeast dipping range—the other half of which is *West Tuscarora*; *Bower mountain*, here an anticlinal but farther west cleft like the former over the axis into two monoclinal ranges. Both these consist of the Medina sandstone, No. IV, and rise to nearly equal height. *Chestnut hills*, which part the waters of Houston's run from those of Sherman's creek as far as Beavertown, are an interrupted ridge or chain of hills crossing the township near its middle and formed of the upbent Iron sandstone and ore sand-rock carrying the Clinton (Bloomsburg) red shale No. V on their slopes.

The Utica and Hudson River shales, No. III.

The description given of these rocks in the report on Toboyne township exactly represents them as they occur in Jackson. Further notice would be only useless repetition.

The Medina sandstone, No. IV.

Six outcrops of this sandstone occur in the township.

1. West Tuscarora mountain forms its northern boundary. This is the northwest dipping half of the Horse Valley arch, and exposes the whole thickness of the formation—both the Upper white and the Lower red sandstone. The latter may be seen on the inner slopes of the Horse valley and the former on the top and outer slope of the ridge.

2. A small fold forms a projecting spur at the northeast end of Horse valley, locally known as the Locking of the Mountains. This divides the end of the valley into two parts, neither of which extends far.

3. Conecocheague mountain. This range consists of the

southeast dipping side of the West Tuscarora anticline. At the east end of Horse valley both sides meet, the small intervening fold disappears, and the united mountains become the anticline of Conecocheague in Madison township. No gap exists along its whole course.

4. Bower mountain. This lofty range passes completely across the township as an undivided anticline with an average height of about 2000 feet above the sea. This range is untraversed by any gap or even low place in the township.

5. A short spur, caused by an anticlinal fold projects from the Blue mountain near the west side of the township into Henry valley, partly dividing it. The southern of the two portions rapidly rises and comes to an end on the top of the Blue mountain, and the synclinal knob thus formed is the southern wall of a deep valley or ravine called Three Square Hollow, in Cumberland county.

6. The Blue mountain forming the southern line of the township and county consist as elsewhere of a monoclinical south dipping range, the other side of which has been completely removed by erosion.

The Clinton group, (No. V.)

The outcrop of the Clinton running along the south slope of Conecocheague mountain is much obscured by wreckage from the crest of the mountain and difficult of access, the ground being covered with timber.

The rocks of this group are, however, well exposed where they are brought up by the axis of Chestnut ridge. This ridge which first becomes conspicuous at Waggoner's mill, near Centre, in Tyrone township, is apparently the continuation of the main axis of the vale of Bloomfield, and consequently of Half Falls mountain, an axis which comes in from the east side of the Susquehanna and traverses the whole of Perry county. It elevates the Onondaga gray shale at the east end of Centre township, the variegated shale almost immediately afterward and as it approaches Loysville the red shale appears at the surface for the first time. Continuing westward it brings up the ore sandrock and green passage shale at Waggoner's mill on the edge of

Jackson township, and begins to form Chestnut ridge. The sand rock is well shown at this point, and is quarried yielding a fair quality of stone. A mile and a half further west, near Centre, Sherman's creek has cut through the ridge and the iron sandstone and lower shale are exposed with a low dip of 15° . Half a mile further west a road passes through making a similar display, but the dip has steepened to 60° . A second gap occurs at a short distance westward where the ridge is again crossed by the creek and a corresponding section exhibited. In this way the axis can be traced across the township into Toboyne, where continually rising it brings up the Medina sandstone and merges into Amberson mountain. Along this axis occur the best exhibitions of the Clinton rocks in the township. At Beavertown narrows and the other gaps already mentioned the various beds are distinctly shown. At Bistline's mill, near Andersonburg, the creek side shows a beautiful arch of the Iron sandstone and Ore sandrock with the lower shales beneath them. Some of these exposures are fossiliferous as that at Beavertown where the upper shales yield abundantly and the lower shales scantily.*

South of this axis another develops itself in the Clinton shales and brings up the Ore sandstone. This axis is much eroded in Jackson township by several streams which have cut their way through it.

The Onondaga shale, (No. V.)

These shales underlie the greater part of the township, including almost all the farming land. They lie along the edges of the Clinton outcrop, but are usually low and covered with soil. They occur in three distinct patches:

1. The valley between Conecocheague and the end of Limestone ridge.
2. The broad open plain in the middle of the township.
3. Shaeffer valley between Bower and the Blue mountain.

* The account here given of this anticlinal axis differs from its description by Prof. Rogers in his Final Report of 1858. In fact I have found it difficult to follow Prof. Rogers' description of the axes of Perry county in the field. His details seem in some places incorrect and confused.

The Onondaga shale in Jackson township has yielded many of the interesting fossils, to be described in Vol. 2. (See Silurian fossil list.)

Section of Onondaga variegated shale from the 19th mile post on the valley road from Bloomfield to Enslow's mill.
See Page Plate XXI.

- Gray calcareous shale with wrinkled or cracked surface.
- 2' Green shale.
- 4' Red shale.
- 1' Brown sandstone and shale.
- 120' Ground imperfectly exposed. In this space is the Bloomfield sandstone.
- 116' Limestone and lime shale, (in soil.)
- Red shale, thin.
- 40' Gray shale and limestone.
- 4' Red shale.
- 144' Gray shale.
- Thin limestone.
- 32' Gray shale.
- Red shale, thin.
- 48' Gray shale.
- Red shale, thin.
- 30' Gray shales with bands of limestone, (spring.)
- 4' Red shale.
- 2' Gray shale.
- 6' Red shale.
- 72' Gray shale.
- 48' Gray and red shale, mostly.
- 3' Yellow shale.
- 125' Yellow and gray shale.
- 801'

The Lower Helderberg (Lewistown) limestone, No. VI.

A broad belt of this limestone enters Jackson township from the northeast, consisting of two synclinal troughs, between which runs an anticlinal axis, (perhaps the fifth of Rogers' enumeration.) The belt of limestone gradually narrows by the disappearance of the southern part, but the northern synclinal continues onward toward New Germantown, narrowing as it passes westward. The synclinal fold is well seen at Mr. Hall's quarries, north of Blain, where about 50 feet of the limestone are exposed. From these

quarries most of the lime used in the west end of the county is obtained. The limestone synclinal which form a high knoll at Blain, gradually sinks until it comes down to the level of the country, and consequently becomes more and more inaccessible. It is, however, quarried by Mr. J. D. Rhinesmith near the western line of the township, and about half a mile north from the turnpike road and on the land of Mr. Kern, near the same place.

The Oriskany sandstone, No. VII.

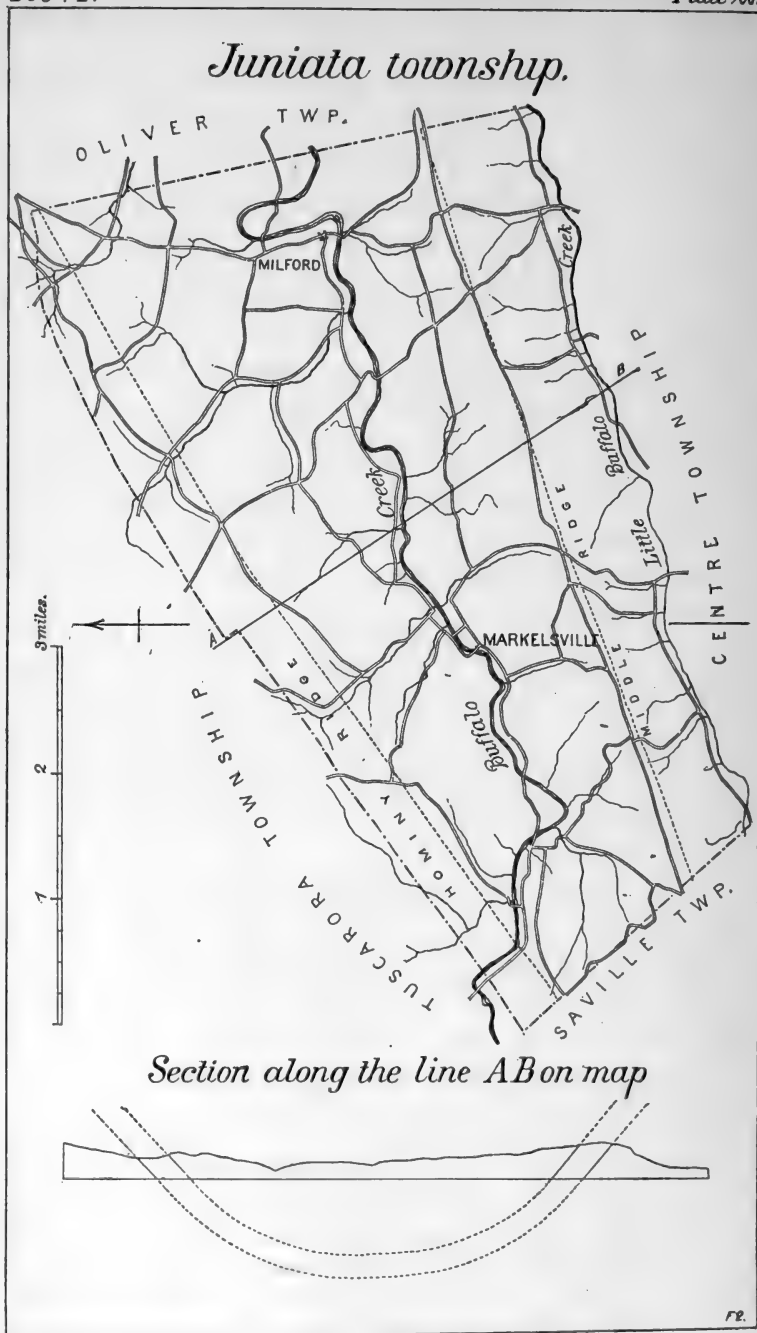
Only a small outcrop of this sandstone occurs in this township in its northeastern portion, where the long tongue projecting from the Sandy Hill synclinal caps the hill that overlooks Blain. It is nearly destroyed here by erosion, and makes no great show. The sandstone is here very ferruginous, much of it consisting of an ochreous yellow sandstone with hard red irregular veins.

7. Juniata township.

Juniata township occupies a four-sided space intervening between Tuscarora on the north, Oliver on the east, Centre on the south, and Saville on the West. It measures about seven miles in length by two and a half in average breadth having an area of about twenty-five square miles. Its surface though hilly is less rugged than that of its neighboring townships, Tuscarora and Centre, and the greater part of it is under cultivation. Middle ridge is the most conspicuous feature. Ranging in a direction from east by north to west by south its gentle slopes are everywhere cleared of wood and cultivated to their very tops. Along its top runs the ridge road from Newport westward through a farming country without villages or hamlets. North and south of this ridge the township is occupied by undulating land of less height.

Most of the small streams of this township coming from Middle ridge and Hominy ridge make their way to the Buffalo, which occupies the middle valley and conveys their united waters into Oliver township. Those, however, that rise on the southern slope of middle ridge flow down into the Little Buffalo which enters the Juniata at Newport.

The Buffalo enters Juniata from Saville and its course lies nearly along the middle of the syncline of the Catskill rocks. Near Juniata it makes a remarkable sweep to the north resembling that made by Sherman's creek in Wheatfield township, and apparently for the same cause. The stream has in its history struck against beds of hard green and red sandstone which occur near the top of the Catskill and by them has been deflected northward. Soon meeting these same beds as they rise from the axis of the syncline it was again turned from its course, this time to



the southward, till it again struck its former barrier along the foot of which it then flowed toward the Juniata.

Since the country was cleared and the drainage improved by clearing the streams the flood plain has been lowered as has happened with other streams in the county. Proof of former greater height of the flood waters is afforded by a thick deposit of red and green clay from which good bricks are made on the land of Mr. Tressler about one mile west of Juniata.

The northern part of Juniata township with the southern part of Tuscarora forms the wildest and bleakest district in Perry county. Hilly but not mountainous, cleared but sterile, with thin soil and that chiefly made of the disintegration of the Chemung shales, it presents little to attract the farmer or the geologist. The best use that could be made of a considerable part of it would be to allow it to go back into timber.

Juniata township includes the smallest number of geological groups found in any township in the county. It is entirely made of the Chemung and Catskill rocks. The great thickness of these two, about 10,000 feet, enables their outcrop to cover a great extent of country and this is doubled by the synclinal axis which passes through the township.

The Chemung group, (VIII.)

This group occupies the northern and southern parts of the township, crossing it in two broad belts from east-northeast to west-southwest. The southern outcrop extends along the line of the Little Buffalo creek the softer lower beds lying under the flat plain of the creek at the east and crossing gradually to the north bank as their dip diminishes. The upper, harder, and sandy portion of the Chemung, rising rather abruptly from the valley and forming the south side of Middle ridge, is a broad rounded range coming into the township from Saville on the west, passing across it as the water-shed between the Buffalo and Little Buffalo, and then leaving it to enter Oliver, where it terminates in the bluff overlooking Newport.

Middle ridge is for the most part cleared and cultivated, but its soil, so far as it consists of the decomposed Chemung shale, is poor and some of it is partially passing back into woodland. At the eastern end the whole ridge is composed of Chemung rocks, but westwardly the red Catskill beds come in and occupy fully half the ground. Along the top runs one of the best roads in the county, Middle Ridge road, affording beautiful views, especially to the northward over Perry, Juniata, and Mifflin counties, to the line of the East Shade mountain. Many small exposures occur along the road ascending Middle ridge from the south but fossils are not abundant though characteristic. They are mostly in bad condition toward the east in consequence of compression, but farther west where the dip is flatter they have suffered less.

The Chemung-Catskill and Catskill, (VIII-IX; IX.)

As the Chemung so the Catskill crosses this township in two broad belts, which, however, occur in the middle of the Buffalo (Lykens valley) syncline and therefore adjoin each other and really form one wide tract, occupying all the middle of the township from east to west. Their outcrop necessarily grows narrower toward the west where it passes into Saville township and thence into the air.

Nearly the whole surface of the Catskill in this township is cleared and cultivated except the steep banks of the Buffalo. The soil is usually good, composed of the decomposed red shale and sandstone with a few intervening yellow and green beds of no great thickness. The lower beds of this group form the top and north slope of Middle ridge except at its eastern end where it is wholly composed of the Chemung shale. They consist of the usual succession of red shale and sandstone and present no feature requiring further notice.

The Kingsmill sandstone, in No. IX.

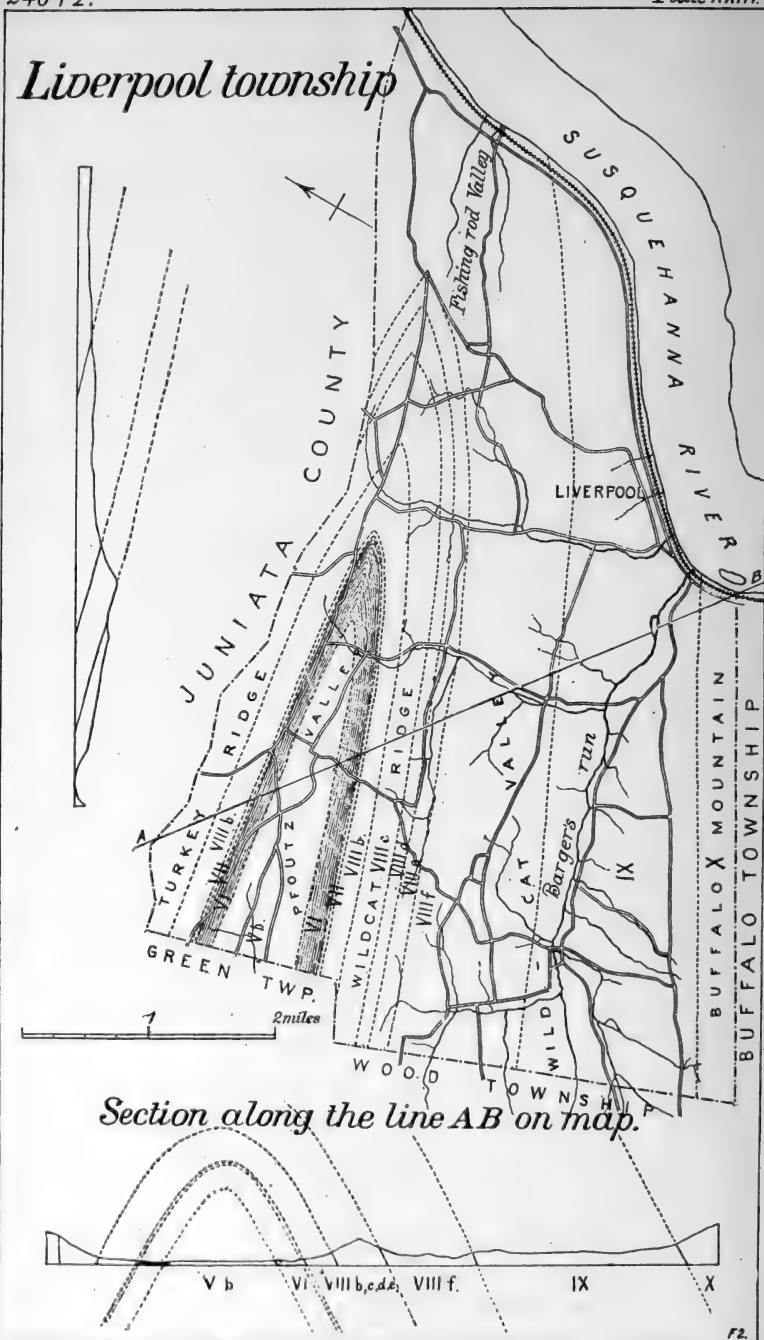
This remarkable stratum, of which a detailed account is given in the report on Carroll and Penn townships, reappears in the Buffalo (Lykens valley) syncline in full force.

Except at the eastern end it forms the northern escarpment of Middle ridge, the top and slope of which are covered with its wreckage. It may be seen on the Ridge road near the western end of the township, but is most conspicuous on the northern side of the syncline west of Walnut Grove school-house, where the land is strewn and the road is fenced with its loose blocks. In texture and appearance it very closely resembles the same bed at its southern outcrop, but fossils are exceedingly scarce. Sufficient, however, have been found to establish its place on palæontological grounds. The position it occupies in Juniata township is analogous to that in Carroll; time, however, did not allow exact measurement.

Buffalo creek has cut its way through the northern wall of the syncline at Walnut Grove school-house, and the rest of its course lies in the trough formed by the Kingsmill sandstone, which otherwise continues unbroken to the Juniata river at Newport and Rope Ferry.

In the upper part of the group occur the hard solid beds of green and red sandstone, which in the southern part of the county form the range of hills skirting the Cove mountain and which are well shown in the cutting on the North Central railroad opposite Duncannon. Here, however, in the north of the county they are much less hard and form no conspicuous ridge on either the east or west side of the Juniata. Their presence is only indicated by a steep low hill skirting the plain of the Buffalo and gradually diverging as the syncline opens toward the river.

Liverpool township



8. Liverpool township.

Liverpool township occupies the northeastern corner of Perry county, and contains about 24 square miles of area. It is less mountainous than its neighboring township, having only one range (Buffalo) that deserves the name mountain. It has for the most part a rolling surface diversified with a few steeper ridges crowned with wood in some places. The eastern end of Wild Cat valley makes up the greater part of the township drained by Barger's run, whose headwaters lie on the water-shed, parting it from the basins of Cocalamus creek, Wild Cat creek, and Hunter's run. The point of Pfoutz's valley enters from Greenwood and forms the northern part of the township, but owing to the softness of the Hamilton sandstone, as noticed under that head, these two valleys are less distinctly marked off from each other in this township than in Greenwood.

The Susquehanna river forms the eastern boundary of Liverpool township. It is more than half a mile in breadth and studded with numerous islands, all of which form part of Dauphin county; the line running along low water-mark on the west bank of the Susquehanna.

In the succession of rocks in Liverpool township a gap is occasioned by the absence of the Oriskany sandstone which makes no appearance anywhere within its limits. Either its beds are so soft as to crumble down and leave no mark on the surface, or, as is more probable, they are very thin or absent.

The exceptionally fine scenery of the Susquehanna river near Liverpool, so instructive to the geologist, is caused by the passage of the river through the two mountain outcrops of Pocono sandstone, leaving four projecting headlands, one pair near and the other distant, gradually narrowing the landscape southward and yielding a most beautiful perspective view down the river. At sunrise or sunset noth-

ing in the county surpasses, for distant effect, the prospect from Liverpool.

The Onondaga shale, (V.)

A slight outcrop of these shales exists in this township, in the northwest, at the east end of Pfoutz's valley. Only the uppermost beds are shown just before they sink under the overlying Lower Helderberg limestone.

The Lower Helderberg limestone, No. VI.

Two outcrops of this formation occur in Liverpool township; perhaps, however, being connected at one end, they should be regarded as one. The northern line enters Liverpool from Greenwood, runs round the east end of Pfoutz's valley, and turning runs W. S. W. along the south side of the valley, leaving the township about a mile south of the place at which it entered. It is well exposed along both lines, and lies so high that it is easily worked. Many quarries have been opened in the township, and a great quantity of lime burnt. The head of Pfoutz's valley is indeed the great store-house for this material for the county round. Of late, however, the kilns at Georgetown, on the opposite side of the Susquehanna, have competed in supplying the eastern part of Liverpool, Susquehanna, and other townships on the river bank. The lime is said to be of better color and quality and is delivered at the same price.

The upper rubbly beds of this group are usually exposed in the quarries. These beds lie below the fossiliferous limestone shales, and above the more solid limestones, and yield very few fossils except the ubiquitous *Leperditia alta*. The beds dip steeply from the middle of the valley north and south in the west of the township, gradually folding round to the east at the place where the two lines of outcrop meet. Here, however, the limestone lies low and cannot be so well or so easily quarried. The flint beds near the top of the limestone are well developed, and form a magnificent ridge in some parts of their outcrop. In many places the land is perfectly covered and white with their wreckage, making its cultivation almost impossible. Fortunately the strip of

flinty ground is never wide. It runs round the edge of the valley outside of the limestone and inside the sandstone of Wild Cat and Turkey ridges.

The Hamilton group, (VIII.)

The outcrop of the Hamilton group enters Liverpool from Greenwood and runs almost due east nearly to the Susquehanna river, where, turning, it runs west-southwest, as shown on the map, reëntering Greenwood. Along its northern outcrop its harder beds from Turkey Ridge. Along its southern outcrop, the same beds show themselves in Wild Cat ridge.

The physical nature of the rocks is not so strongly contrasted as in the middle townships of Perry county. The change is very conspicuous in the sandstone. In Centre and neighboring townships it is very hard, 500 or 600 feet thick, always forming steep, rugged, and wooded hills. Here in Liverpool its beds are much softer and less sandy. The proportion of shale is greater. In consequence the ridges which it forms are less abrupt and rocky. Wild Cat ridge and Turkey ridge lose much of their steepness as they approach the Susquehanna, and in many places are cultivated to their very tops. Pfoutz's valley is therefore not so well defined at its eastern end as near the Juniata river. Its bounding ridges sink and becoming comparatively insignificant, are crossed by numerous roads without the roughness and steepness that usually mark roads on the Hamilton sandstone.

The point of the angle formed by the meeting of the two outcrops of the Hamilton sandstone lies between one and two miles from the river and forms the eastern termination of Pfoutz's valley, itself the eastern end in Perry county of the long Tuscarora anticline, of which more will be written under the head of the Chemung group in Liverpool township.

The Genessee, Portage, and Chemung groups, (VIII.)

The outcrop of these rocks may easily be traced on the geological map of the township given herewith. They fol-

low the same direction as the other groups and fold over the eastern end of the sinking arch which runs for so long a distance across the county, and forms for many miles the boundary between Perry and Juniata counties. At the Susquehanna river the Chemung rocks carry the arch. Compare the section of the western part of Pfoutz's valley in the report on Greenwood township with the section of its eastern end. See Page Plate XXIII, p. 240, Fig. 3.

The Chemung-Catskill, and Catskill, No. IX.

The red sandstone and shale of this group are well exposed in many places in this township, for example near Liverpool, where a long and continuous section through its upper beds may be seen along the stream forming the north branch of Barger's run. This section extends with few interruptions from the Susquehanna river to the grist mill, nearly a mile and a half. As the beds dip very steeply, at an angle of about 70° , and the brook flows nearly at right angles to the strike the thickness of the part of the group is easily calculated. It amounts to between 6000 and 7000 feet. The section does not quite reach to the top of the Catskill but includes the basal beds of the series, which are marked here as elsewhere in the county by the occurrence of layers of yellowish shale and of thin, square-fracturing, fine-grained sandstone similar to that of the Upper Chemung, interbedded with red shales and sandstones.

The group is not well exposed along the Susquehanna river owing to the great erosion.

The Catskill rocks occupy a broad belt in the southern part of the township. Their southern limit lies nearly along the road at the foot of Buffalo mountain and its northern nearly coincides with a straight line drawn from the grist mill above mentioned to a point a few hundred yards north of Liberty Hall, and extended to the Susquehanna river near Dry saw-mill.

Its surface yields good land for cultivation and is diversified with hills and valleys and well watered.

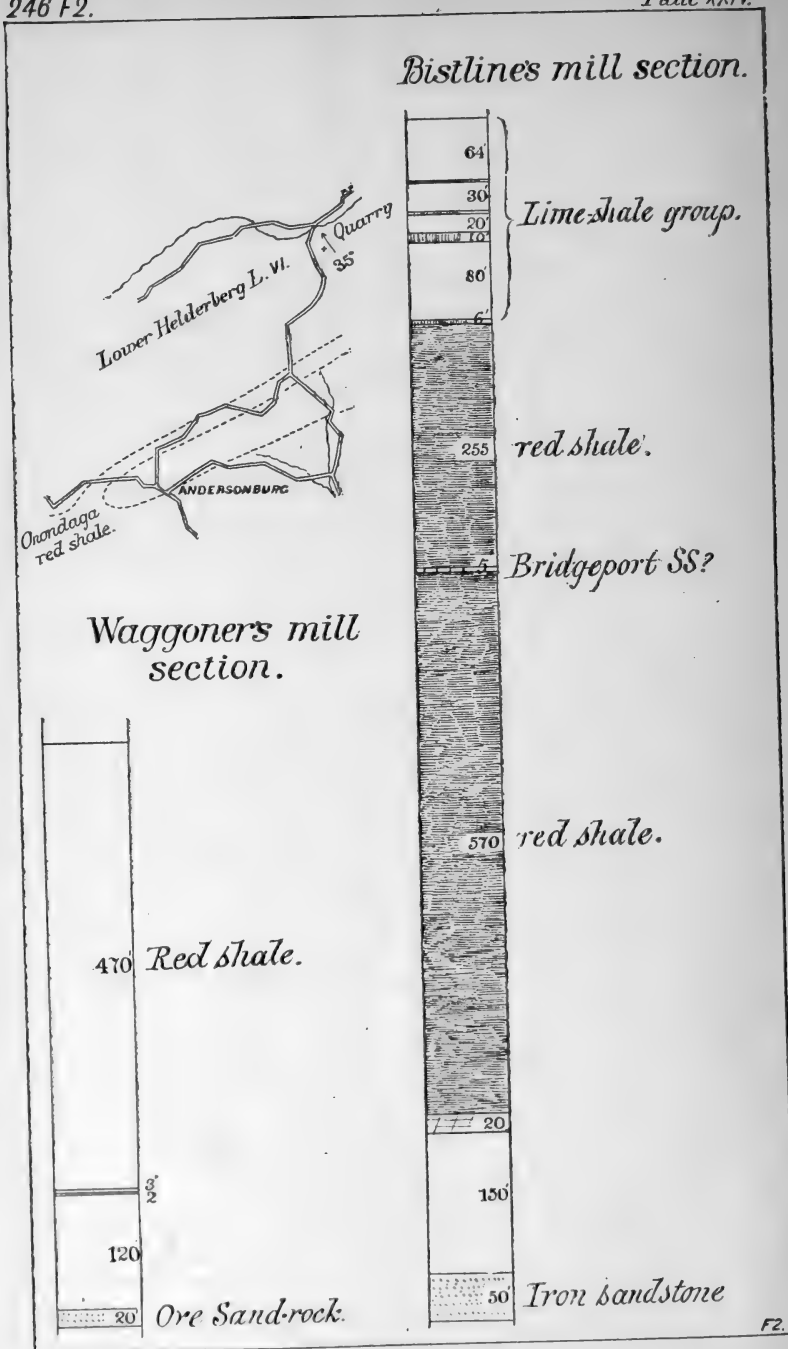
In some places near Liverpool good flagstones are quarried from the red sandstone of this group.

The Kingsmill sandstone, of which a description was given in the report on Wheatfield township, runs from Greenwood (see report on that township) through Liverpool to the Susquehanna river. It forms a stony ridge difficult to cultivate and consequently left for the most part in timber. This sandstone may be found about two miles north of Liverpool near Dry saw-mill. No actual exposure of the bed was discovered, but in the stone-piles scattered over the fields several of the fossils so abundant in this rock at its typical exposures in Wheatfield township were found. There can be little or no doubt that this bed extends or once extended over all the eastern part of Perry county near the base of the Catskill group.

The Pocono sandstone, No. X.

The crest of Buffalo mountain is the dividing line between Liverpool and Buffalo townships. This mountain runs in a straight line from the Juniata to the Susquehanna, where it has been cut down by the river in order to afford an escape for the water of the upper country. This gap forms one of the picturesque features of the scenery at Liverpool, and combines with that through Berry's mountain, three miles below, to form the magnificent semi-panoramic view so much admired by visitors and residents.

The slope of Buffalo mountain in this township is, like that in Greenwood, covered with timber so that the mountain side is in summer an unbroken green wall cutting off these two townships from Howe and Buffalo to the south.



9. Madison township.

Madison township, like Jackson and Toboyne, reaches across Perry county from Tuscarora to the Blue mountains. It is one of the large townships, measuring about ten miles from north to south by six from east to west, and consequently contains nearly 60 square miles.

Its northern and southern portions are mountainous, but the middle is open and tolerably level, except that it is divided by Chestnut ridge through which, however, several gaps have been cut by Sherman's creek.

The northern part of this middle portion consists for the most part of a limestone soil, and the land is strong though rather cold in the spring and hard to work. The southern portion lies on the shales of the Clinton and the Onondaga, and is for the most part a red warm soil.

Chestnut ridge rising on the eastern line of the township consists of an anticline which brings up the harder beds underlying the red shale. The Ore sandstone and the Iron sandstone form the axis. Both are thin and are consequently cut down with ease. Hence the numerous gaps.

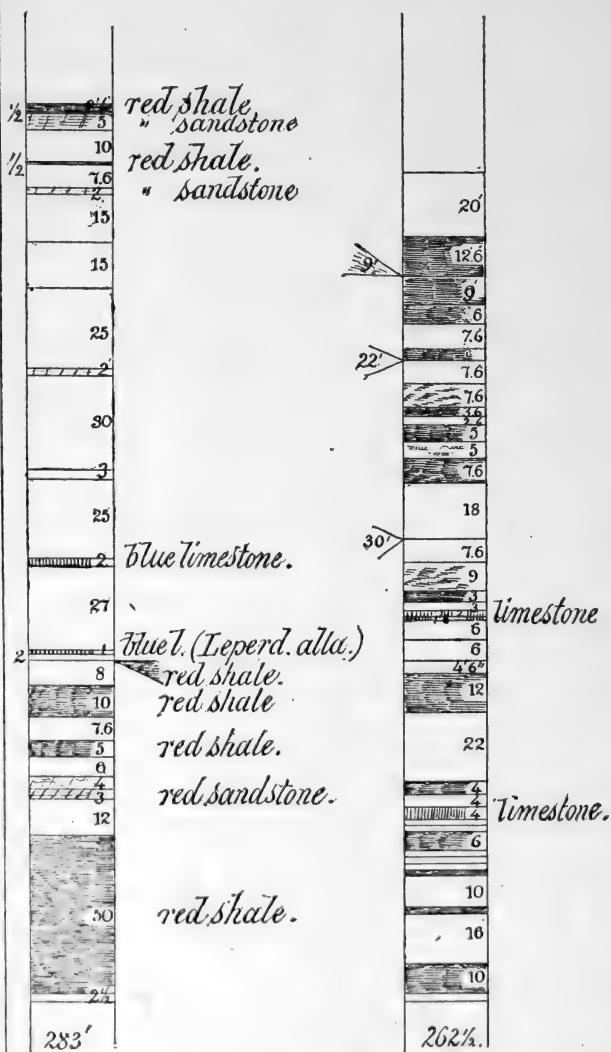
The anticline which brings up Chestnut ridge passes on southwestward and culminates in *Amberson's mountain* on the county line.

Another ridge without name extends across the township further north, running from *Sandy hill* southwestward. It consists of the Lower Helderberg limestone No. VI, capped by a synclinal outcrop of the Oriskany sandstone No. VII, which latter is cut down and ends near the west line.

Conecocheague mountain rises north of this last named ridge. It is an anticline of Medina sandstone No. IV, undivided and even-crested. Steep and rough it forms an effectual barrier between the dwellers on its two flanks in

Onondaga Limestone.

Cissna's Run section Centre section.



the west of the township, but being lower at the east where the Medina arch sinks it is there crossed by two roads.

East Tuscarora mountain, like *Conecocheague*, is an undivided anticline running with even and unbroken crest from one side of the township to the other. It is an arch of the Medina sandstone from the top of which the softer shales have been removed. It is rough, steep, and covered with wood, and no road passes over it in this township.

Bower mountain in the south, like the two already mentioned, is, in Madison township, an undivided anticline of Medina sandstone. It rises gradually from the level of the surrounding country with a high and even crest which continues until it passes into Jackson. A small farm exists upon the very ridge.

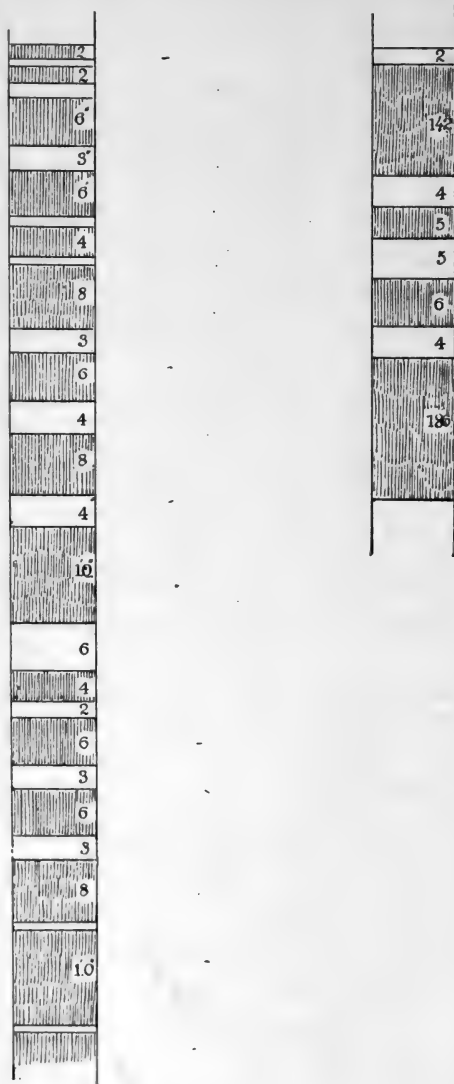
Blue mountain, in Madison township, consists of a monoclinal nearly vertical range of Medina sandstone flanked on the north by the iron sandstone. These include between them the Clinton lower shale. It forms the line between Perry and Cumberland counties. A road passes over it at one place into Doubling hollow.

Between the mountains lie the following parallel valleys :

(1) *Liberty valley* between East Tuscarora and *Conecocheague*;—(2) A narrow red shale valley between *Conecocheague* and the Oriskany ridge;—(3) *Centre valley*, between the Oriskany ridge and Chestnut ridge;—(4) A valley between Chestnut ridge and Bower mountain;—and (5) *Shaeffer valley*, between Bower and Blue mountain.

(1). *Liberty valley* is a continuation of what is called in its eastern portion *Raccoon valley* and *Buffalo valley*. It begins where the rising axis of *Conecocheague* forms a barrier between it and the red shale valley to the south of it and continues into Juniata county forming the third natural road between the two counties, the other two being near Liverpool and Millerstown. It is a good farming district with warm fertile soil.

(2). This valley which has, so far as I can learn, no definite name, but might be called the *Ickesburg valley*, is produced by the elevation of the *Conecocheague* axis and widened by the two other short anticlines of which mention

*Marcellus limestone.**Tudor's quarry section. Rice's quarry section.*

is made in the report on Saville township. It widens towards its southwestern end in consequence of the gradual narrowing of the long synclinal limestone tongue extending westward to Blain. It is, like the preceding, composed of the red variegated and gray shales under the limestone and the soil is consequently good.

(3). *Centre valley* includes the best agricultural portion of the township, consisting largely of land derived from the decay and disintegration of the Lower Helderberg limestone No. VII. This is brought up by a set of anticlines which will be found described below and which close the western end of the Buffalo mountain trough. Geologically the limestone is here in a number of slight folds with moderate dip, the synclinal lines of which are indicated by higher and the anticlinal by lower ground.

(4). The valley between Chestnut ridge and Bower mountain consists wholly of the shales of the Onondaga group. These are exposed in many places along the banks of the creek but in general this valley is little cultivated and thinly settled.

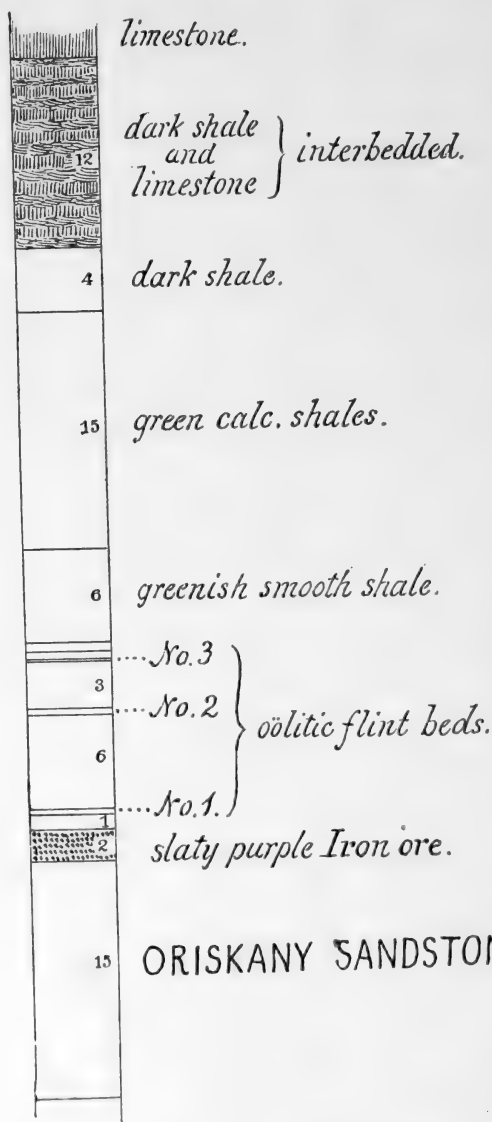
(5). *Shaeffer valley* is, like the preceding, a valley consisting altogether of the shales. It is narrow and rough, much covered with timber and in its upper parts little frequented.

Five parallel anticlinal folds involve the rocks from the red shale No. V to the Hamilton sandstone No. VIII, and possibly some yet higher in the series. The thick beds of the Hamilton and Chemung flatten as they rise westward into the air, and then the underlying limestone is traversed by these small rolls in the bottom of the great trough.

The synclinal lines of limestone differ in length. The most northerly extends out of Madison through Jackson into Toboyne township, but the more southerly scarcely extends beyond Cedar run, in Madison township.

The Hamilton sandstone is affected by the more northerly of these axes near Sandy Hill, where a distinct syncline occurs described in the report on Saville township. But further south this massive sandstone seems to have been a resistant bed and its undulations are slight.

Marcellus limestone.
Centre Mills section.



Sherman's creek carries nearly all the water from the township. Entering from Jackson at Bistline's mill, about the middle of the west line of the township, it turns south, cuts through the Chestnut Ridge anticlinal, flows for a mile and a half to the south of it, turns north, again cuts through the same anticline, and after passing Centre crosses it for the third time, and continues to flow south of it.

Buffalo creek drains the eastern end of Liberty valley and passes into Saville township.

A small area in Liberty valley is drained into *Tuscarora creek* by the *Horse Valley run*. The central part of Madison township is drained by a stream rising with a double head in the narrow valley south of Conecocheague mountain. Thence it flows south over the confused ground broken by the small anticlines in the east of the township to Centre mills, and soon afterwards enters Sherman's creek. It seems to have no settled name along its whole course, but might well be named Centre run.

Laurel run or *Murray's run*, the lower part of which has been also known as *Patterson's run*, brings down the water from Shaeffer valley and Henry valley, which is only its westward continuation and pours it into *Sherman's creek* near Landisburg. It is for the county a considerable stream and remarkably straight, being hemmed in between Bower and the Blue mountains so that it cannot swerve from the nearly direct course of those ranges.

The Medina sandstone, No. IV.

Five outcrops of the sandstone are found in the township, viz: (1) East Tuscarora mountain; (2) West Tuscarora mountain; (3) Conecocheague mountain; (4) Bower mountain; and (5) Blue mountain.

These have been sufficiently described above, except the second, only a small part of which lies in Madison township. It is brought up by the Horse Valley anticlinal and forms a bold headland projecting into Liberty valley from the west and effectually blocking all passage between the two valleys. This anticlinal knot is aptly named in the district the "Locking of the Mountains."

The Clinton group, (V.)

The various beds of this group form no small part of the surface rock in Madison township. Their northern is separated from their southern outcrop by the intervening compound synclinal belt of limestone occupying the middle of the township. The various divisions of the group are the same as those given in the account of Saville township.

5. The Sand-rock ore bed.
4. The Ore sand-rock { Upper, soft.
Lower, hard.
3. The Upper Olive shale. Fossil ore group.
2. The Iron sandstone.
1. The Lower Olive shale.

The Clinton lower shale is well exposed on the road over Conecocheague from Buffalo mill to Sandy hill, where it is brought up by the axis of Conecocheague and not concealed beneath masses of the wreckage of the Medina sandstone as is the case on the slopes of Tuscarora. At this part of the anticline the mountain consists entirely, so far as its top and slopes are concerned, of the Clinton group as defined above and the red and variegated shales which overlies them.

The Iron sandstone rising on the Conecocheague anticline forms terraces on the north and south slopes of the mountain which are much encumbered with the flat red plates of this durable rock. The outcrop is of especial interest, however, for having afforded the fossils of which an account will be found in the volume on the palæontology and also in the appendix.

The Iron sandstone seems to thicken rapidly in this township. Its wreckage and terrace at Run gap are both inconspicuous but both become evident at a short distance west of the gap and in Conecocheague are strongly marked. The upper olive shale is not well exposed but may be found at some places along the slopes of Conecocheague and betrays itself by the color of the soil.

Loose fragments of the *Ore sand-rock* are also abundant in the same place but the rock does not, so far as I am aware, occur in position. Some of its beds here are very fossiliferous.

The *Sand-rock ore bed* probably runs along the whole length of Conecocheague mountain in this township but has nowhere been opened. To this bed must be referred the reported discoveries of iron ore in the district.

It is of little use to seek outcrops of these rocks on the south slope of Tuscarora, for the immense mass of wreckage that has fallen from the Medina sandstone near the summit has buried them beyond reach.

Bistline's Mill section, (V.)

64'	Gray shale,	} 212
	Thin limestone,		
30'	Gray shale,		
2'	Shaly limestone,		
20'	Shale,		
10'	Limestone, (once quarried,)	} 220'
80'	Shale,		
6	{ Lime shale,		
	{ Limestone,		
255'	Red shale,	}	Bloomsburg red shale, 830'
5'	Bridgeport sandstone, (?)		
570'	Red shale,	} 220'
20	Ore sand rock,		
150'?	Olive shale,		
50'	Iron sandstone,		
			1262'

This section deserves notice as it is the only place where I have seen a sandstone, the equivalent of that at Bridgeport or another resembling it, where its position could be ascertained.

The Onondaga shales, (V.)

These shales occupy their usual position in the township, that is on the top of the rocks composing the Clinton group. They are, therefore, found in the middle of the synclines such as Liberty valley and Shaeffer valley, the valley between Bower mountain and Chestnut ridge, &c., or near the base of the Lower Helderberg limestone, and dipping under them. They may be subdivided thus :

Gray calcareous shales
Bloomfield sandstone.

Variegated shales, (calcareous.)

Red shale, (calcareous.)

A good section through the greater part of the red shale is shown west of Waggoner's mill along the roadside, with a continuous dip of from 15°-30° N. N. W. The Ore sand-rock is quarried in the hill at the top of the section, and about 120 feet of olive calcareous shale with a bed of fossiliferous limestone succeed it. Then follow about 450 feet of red shale which do not include the whole of the stratum.

Waggoner's Mill section, (V.)

470' + Red shale exposed with dip from 0°-80° in middle of syncline.

3' Four small thin beds of green shale.

2' Hard green sandstone. Dip 70°.

120' Space concealed, but the lime shales and sandstone show in field east of mill with abundance of *Beyrichia notata*.
Dip varying.

20' Ore sand rock. Dip 10° S. S. E., Total, 615'
Green shale.

Cissna's (Cedar) Run section, (Onondaga.)

The road running south from the main turnpike road through the valley shows an interesting section across the beds lying at and below the base of the Lower Helderberg limestone. They are the Scalent variegated marls of the first survey, and in part the Scalent gray marls overlying them. A noteworthy point is the existence of *Leperditia alta* almost to the bottom of the section so far below the base of the limestone.

It must also be remembered that the top of this section is many feet below the true limestone beds which are shown about a mile to the westward, but a section of which can scarcely be obtained there. Near Robert Clark's farm on the roadside the limestone beds may be followed down each, containing *L. alta* until they appear to be almost pure argillaceous shales.

Cissna's Run section.

Top of section. Green shale in main road.

Red shale,	2' 6"
Bright green sandstone,	6"
Red sandstone,	5' 0"
Green and yellow sandy shale,	10' 0"
Red shale,	6"
Green shale,	7' 6"
Hard red sandstone,	2' 0"
Dark shale,	15' 0"
Yellow shale,	15' 0"
Solid dark shale,	25' 0"
Sandstone,	2' 0"
Dark shale weathering yellow,	30' 0"
Green shale,	3' 0"
Dark shale,	}
Yellow shale,	
Green shale,	25' 0"
Solid blue limestone,	2' 0"
Yellow shale,	27' 0"
Solid blue limestone, <i>Leperditia alta</i> ,	1' 0"
Green shale,	2' 0"

Space covered 20 feet.

Red shale.	
Green shale,	8' 0"
Red shale,	10' 0"
Green shale,	7' 6"
Red shale,	5' 0"
Yellow shale,	6' 0"
Shaly green sandstone,	4' 0"
Red sandstone,	3' 0"
Green shale,	12' 0"
Red shale,	50' 0"
Green shale,	2' 6"

Base of section. Ground not exposed.

283' 0"
Section of Onondaga variegated shales west of Centre.

A good section of part of the variegated shales, apparently the same beds as are displayed in the railway cutting at Patterson, (Mifflintown,) is shown on the side of the turnpike road at a short distance west of the village of Centre. At the top of the section the dip is 30° N.

Centre section, (Onondaga, No. V.)

Green shale,	20' 0"
Red shale,	12' 6"
Green shale,	9' 0"
Red shale,	6' 0"
Green shale,	7' 6"
Red shale,	3' 6"
Space covered 22 feet.	
Green shale,	7' 6"
Green shale mottled with red,	7' 6"
Red shale,	3' 6"
Green shale,	2' 6"
Red shale,	5' 0"
d. Green shale with thin bed of limestone,	5' 0"
Red shale,	7' 6"
Green and yellow shale,	18' 0"
Space covered 30 feet.	
Green shale,	7' 6"
Green shale mottled with red,	9' 0"
Red shale,	3' 0"
Green shale,	3' 0"
c. Sandy limestone, coarse,	2' 0"
b. " " fine,	1' 6"
Yellow shale,	6' 0"
Dark shale,	6' 0"
Green shale,	4' 6"
Red shale,	12' 0"
Green shale,	22' 0"
Red shale,	4' 0"
Green shale,	4' 0"
a. Dark flaggy limestone,	4' 0"
Yellow shale,	2' 0"
Green shale,	2' 0"
Red sandy shale,	6' 0"
Light green shale,	2' 0"
Yellow shale,	2' 0"
Green shale,	2' 0"
Red shale,	2' 0"
Yellow shale,	10' 0"
Red shale,	2' 0"
Green and yellow shale,	16' 0"
Red shale,	10' 0"
Green shale,	2' 0"
Base of section just before reaching turn of road.	
Total thickness exposed,	<u>262' 6"</u>

Red shales follow through Centre with a strike parallel to the road and heavy red sandstone at tannery just below the base of the section.

The bed *a*, though a very calcareous shale in hard solid but thin layers, yielded no fossils except a doubtful mark or two.

The bed *b* is little beside a perfect mass of shells of *Leperditia alta*, apparently the same as that occurring at Paterson, Juniata county, (see note,) in the railway cutting through the same shales at that place. The material also of the bed is very much like that of the Paterson bed. The bed *c* is really the lower part of *b* but is harder, more brittle, and breaks with a square fracture. It consists, like that above it, of the shells of a *Leperditia* of the same species apparently.

The bed *d* is a hard, dark, close limestone yielding very little except a *Leperditia* ill preserved but probably the same as that in the beds below it, *b* and *c*.

The Lower Helderberg limestone, No. VI.

The northern-central part of this township is occupied by a broad sheet of this limestone thrown into low undulations or waves. The erosion of all the overlying strata has exposed this bed, the disintegration of which constitutes a broad hilly district of good fertile land. Four, if not more, of these small anticlines traverse the limestone, producing a constant change of dip, and bringing to the surface different beds in different places.

The Blue Limestone beds.—These beds which form the most valuable material for limestone are well exposed at numerous places. At Adairs' quarry west of Centre about 25 feet of this formation can be seen dipping into the hill at 20°–25° north-northwest. The lowest beds are the thickest, those above becoming gradually thinner.

The Shaly Limestone beds.—These beds—the Premeridian Limestone of Rogers—are seldom opened in consequence of the nearness of the more solid bed below them. But near Bixler's mills a quarry shows the upper part of them from the *Meristella* beds up to the *Tentaculite* and *Flint* beds. The usual fossils may be collected here but the exposure is not large.

A small quarry on the roadside, near the house marked

C. Shull on the county map, shows the lime shales of the Lower Helderberg, and the following section can be made out. Dip 35° N. 30° W. See Plate XXIV

Shaly limestone beds with <i>Discina discus</i> and a small sp. of Favosites,	3'
Crinoidal beds,	3'
Trematopora beds,	1' 0"
Shaly beds with <i>Meristella laevis</i> and <i>M. bella</i> , <i>Tentaculites gyracanthus</i> ,	12' 0"
Crinoidal beds,	2"
Shaly bed with a few specimens of <i>Rhynchonella formosa</i> ,	1' 0"

The Oriskany sandstone, No. VII.

The outcrop of the Oriskany sandstone in Madison township follows a line of considerable length. Entering from Saville near Sandy hill it runs in nearly a straight line across the township and for a short distance into Jackson. Thence returning the syncline opens about the middle and the southern limb, diverging from the northern, runs south of Sandy hill and ends as an anticlinal ridge the south side of which returns south-westward for about a mile and then zigzags back and forth several times till arriving near Centre township, it passes east out of the township along the north side of the Limestone ridge.

The Oriskany sandstone in Madison township is much softer than in the centre of the county. It consequently makes no conspicuous ridges and is with some difficulty traceable over the ground. It is also more ferruginous and more fossiliferous. It is consequently deep yellow or red in color and yields a very sandy yellow soil. The dip for the most part is gentle and the anticlinal folds to which allusion has been already made show little steepness. It would be exceedingly difficult to trace these folds were it not for the outcrop of the Oriskany.

The Marcellus lime-shales and limestone, (VIII.)

This is the most interesting stratum to the geologist which Madison township affords. Its exposures are here more abundant and more nearly complete than anywhere else, and it is chiefly from this township that I have collected

the evidence, both stratigraphical and palæontological, which has enabled me to assign its true position.

The limestone in question has been regarded as the representative of the *Corniferous formation* of the New York series, solely on account of its position at the base of the Marcellus black shale. But no trace of the great deposits of flint which characterize that horizon in New York are found in Perry county. Nor have any Corniferous fossils afforded to the palæontologist satisfactory evidence of the correspondence of the two strata.

Several good though partial sections in Madison township afford valuable stratigraphical evidence in favor of a different opinion. The following are the details of the exposure at Dr. S. M. Tudor's quarry near Centre Mills, where the stone is quarried for building and for burning. It will be seen from the section that the limestone beds here are very solid :

Tudor's Quarry section, (bottom of VIII.)

Limestone,	2''	Limestone,	12''
Dark shale,	1''	Dark shale,	6''
Limestone,	2''	Limestone,	4''
Dark shale,	2''	Dark shale,	2''
Limestone,	6''	Limestone,	6''
Dark shale,	3''	Dark shale,	3''
Limestone,	6''	Limestone,	6''
Dark shale,	1''	Dark shale,	3''
Limestone,	4''	Limestone,	8''
Dark shale,	1''	Dark shale,	1''
Limestone,	8''	Limestone,	12''
Dark shale,	3''	Dark shale,	1'
Limestone,	6''	Limestone,	
Dark shale,	4''		
Limestone,	8''		
Dark shale,	4''		
			<hr/>
			10' 7''
			<hr/>

Here is a series of *fifteen beds of limestone* alternating with *fourteen beds of dark shale* exactly resembling some parts of the Marcellus shale. It is black when wet, but dries to a peculiar reddish tint as do many of the layers in the Marcellus proper. There is no impropriety, therefore, or stratigraphical evidence in referring the whole mass in question to the Marcellus, and this conclusion is corroborated by the presence of Marcellus fossils in several of the lower

beds of black shale. The strata at this quarry dip very gently to the N. N. W. at about 2° – 5° .

Another small quarry opened on the adjoining farm of Mr. D. Rice shows the following section :

Rice's Quarry section.

Black or dark shale,	2''	} 4 7''
Limestone,	14''	
Dark shale,	4''	
Limestone,	4''	
Dark shale,	5''	
Limestone,	6''	
Dark shale,	4''	
Limestone,	18''	
Dip 2° – 5° N. N. W.		

Both these sections are in the Marcellus limestone overlying the Marcellus lime shales, and exhibit the limestone in the most solid form in which I have seen it in the county. The decrease in the limestone and relative increase of the shale towards the top is obvious.

West of Centre Mills is a section of rocks dipping 40° to the north, as follows :

Centre Mills section, (bottom of VIII.)

<i>Limestone.</i>	
Dark shale and limestone interbedded,	12'
Dark shale,	4'
Greenish calcareous shales,	15'
Greenish smooth shale,	6'
Sandy green shale,	6''
Soft green shale weathering red,	6''
Flinty oölitic bed square-fracturing, No. 3,	2''
Green rubbly shale weathering red,	3'
Hard flinty bed, oölitic, No. 2,	4''
Green rubbly shale, weathering red,	6'
Dark oölitic hard bed, No. 1,	4''
Blue clay,	1'
Iron ore, slaty, liver colored,	2'
ORISKANY SANDSTONE, soft,	15'
65' 10''	

This section gives the base of the Marcellus lime-shale down to the Oriskany sandstone. It is obvious that the amount of lime rapidly increases upward and the amount

of dark shale diminishes. The gray calcareous shale at the base of the group gives place to an alternation of dark shales and limestone, the latter in very solid, hard beds, as shown in the preceding sections. These beds have yielded numerous fossils for an account of which the reader is referred to the volume on the palæontology.

The Marcellus black shale, (VIII.)

Good exposures of this rock may be found in Madison township. It is thrown out by the low folds of which mention has already been made, and made be found exposed by the wayside in many places between Bixler's mills and Sandy hill. It presents, however, no unusual features and calls for no further remark at this outcrop.

A strong sulphur spring issued at Sandy hill, at H. Kepner's, probably from black slate. At * * in Fig. 3, plate XXIV, the Marcellus limestones make a good show along the roadside, but in a passing examination I saw no fossils.

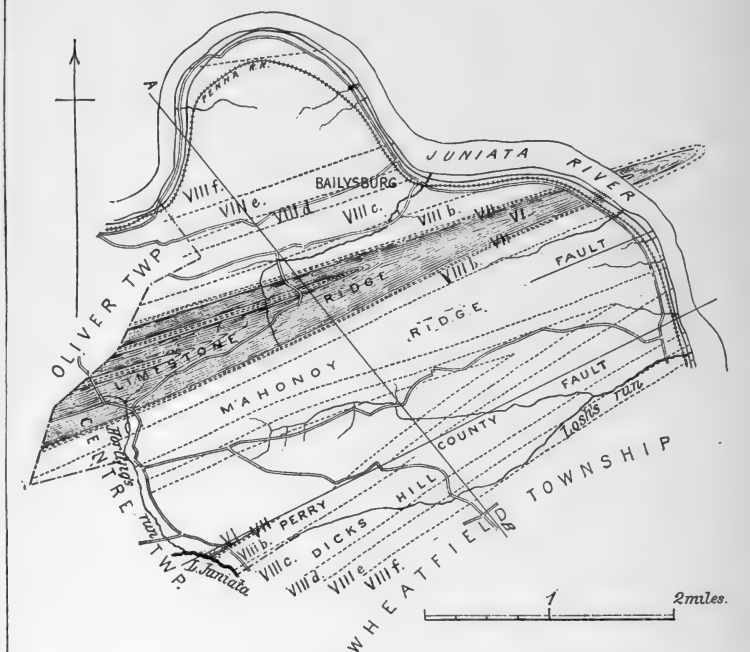
The Marcellus Iron ore.

This ore crops out near sandy hill and makes a very fine display along the roadside. Many tons might readily be gathered up and an abundant supply obtained by mining. But without railway carriage it is of little or no present value.

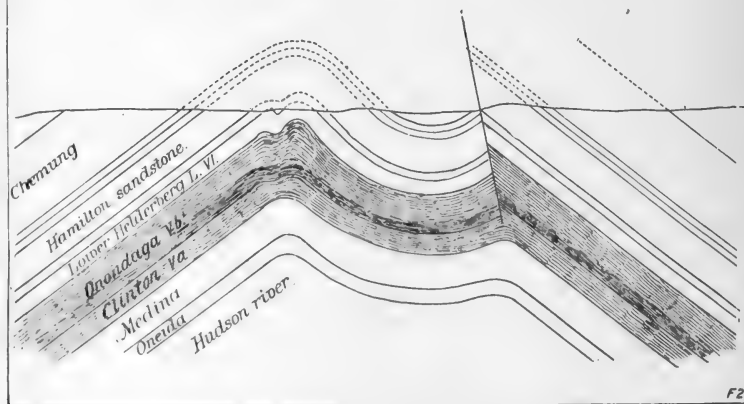
The Hamilton lower shale and sandstone, (VIII.)

These beds make but an insignificant show in Madison township entering it from Saville, and there is no occasion to do more than refer the reader to the report on that township for all necessary details.

Miller township.



Section along the line AB on map.



10. Miller township.

This township occupies the great bend of the Juniata from the border of Oliver on the north to that of Wheatfield on the south. It touches Centre for a short distance on the west, but its longest boundary is the Juniata river. It occupies a greater length of the bank of this river than any other township in the county.

Four distinct parallel ridges traverse Miller township from east-northeast to west-southwest, and determine the main features in its physical geography—Buffalo hills, Limestone ridge, Mahanoy ridge, and Dick's hill. No stream of any importance is found within its limits. The largest is Losh's run, which drains its southern portion, and of which one arm forms its dividing line from Wheatfield township. The basin of this stream is bounded by Mahanoy ridge and Dick's hill. Another stream of smaller size, Bailey's run, drains the narrow basin between Mahanoy ridge and Limestone ridge, and falls into the Juniata at Baileysburg.

Miller township is divided into two parts by the triple ridge that traverses it as mentioned above. Its three parts diverge from the central knob or focus in Watts township where they all take their origin. They have no gaps except at Pine Grove and Baileysburg, which will be found described in the chapter on the Hamilton sandstone.

In consequence of its structure a great portion of this township is covered with timber. The high ground on the Upper Chemung in the peninsula, the slopes of Buffalo and Mahanoy, the ridges south of Mahanoy and Dick's hill are almost entirely wood-clad. Much of Limestone ridge is also in the same condition, especially where its surface is strewn

with loose blocks of Oriskany sandstone or traversed by Oriskany ridges.

The Perry county fault is a conspicuous feature in the geology of the township. Entering from Centre it passes along the north foot of Dick's hill, and then suddenly diminishing continues with less and lessening throw across the township to the river. Its effect in the western part of the township is to bring the Lower Helderberg limestone against the Chemung shales. Further east the Hamilton sandstone comes against the Chemung, then the Hamilton upper shale until finally by the development of a second and parallel fault to the northward, the outcrop of the Hamilton upper shale is thrown so far south that the Chemung is altogether cut out before it reaches the river, and the two outcrops of Hamilton upper shale meet round the end of the syncline in or about the river, and the Perry county fault disappears. To trace its exact course and throw across the flat low ground near the river is, however, difficult, and the above description may therefore be inaccurate in some of its minute details.

The Lower Helderberg limestone, No. VI.

Three distinct outcrops of this limestone occur in Miller township. The first and most northerly is a very narrow anticline coming in from Oliver and passing a few hundred yards north of the washer at the iron ore works. It scarcely shows more than the very highest beds, such as the flint bands, and dies out about the middle of the township. It is the continuation and ending of Limestone ridge, or at least of that part of it lying on the north slope of Inoculate hill between Bloomfield and Newport.

The second outcrop is parallel with the first and is a continuation of the two limestones on the north and south sides of the vale of Bloomfield. These unite near the township line owing to the disappearance of the red shale, which sinks below the surface to the eastward, and pass along as a single anticlinal outcrop to the Juniata river. Numerous quarries, large and small, have been opened in it. Most of these

are in the lower solid beds and few of them expose the fossiliferous limestone shales.

The third outcrop of the limestone in the township is an isolated patch brought up by the Perry county fault on the north side of Dick's hill. Part of the outcrop lies in Centre township but it extends for about a mile in Miller township and several quarries have been opened in it. These quarries owing to the fault are all within a few hundred feet of the Chemung shale. At the western line of the township the strata are overthrown so that the Marcellus shale overlies the Hamilton sandstone, but the dip changes and the limestone, as explained elsewhere, soon disappears in consequence of diminished throw.

The Oriskany sandstone, No. VII.

The outcrops of the Oriskany sandstone in Miller township show traces of that complication which is so marked a feature in the geology of Centre township. Beginning as a simple anticlinal ridge in Watts and Buffalo where it is raised by the limestone in the western end of Half Falls mountain the Oriskany crosses the Juniata as a double ridge, the southern line of which forms an almost complete dam in the river. The effect of the northern line of outcrop is much less strongly marked, probably because the water is dammed back over it by the southern outcrop, which will be described first.

First outcrop.—Continuing in almost a straight line to the west-southwest it runs nearly parallel with the New Bloomfield and Baileysburg road for some distance to Pine Grove, where it passes close behind an ancient graveyard* and a church and about a mile farther on enters Centre township, where a gap in Mahanoy ridge allows the water to pass to the southward.

A second ridge of Oriskany sandstone appears along the

*This graveyard, belonging to one of the three original Presbyterian churches in the county, was built ten years before the Revolutionary War or about 1766. The church has long been removed but the graveyard is still in tolerable preservation.

northern side of the anticline ranging from Half Falls mountain over the Juniata, which it crosses about 100 yards north of the ridge already described. Thence continuing west-southwest and gradually diverging from the former it crosses the road from New Bloomfield to Baileysburg nearly on the line of the run, and continues along the south foot of Buffalo hills rising gradually with the land until it is found again crossing the road that passes by the Clouser ore works about 100 yards north of the washer. Continuing through the woods its outcrop may be traced through Oliver township across the New Bloomfield-Newport road on the north side of Inoculate ridge in Centre township. Along some part of its course this line of outcrop forms a rough ridge of rocks, but in most places it is inconspicuous compared with that to be next described.

The third outcrop of Oriskany sandstone in the township occurs as a synclinal fold between the two already mentioned. Beginning in the low ground about two miles west of Baileysburg, it rapidly rises into prominence and forms the crest of Inoculate ridge, which continues in an almost straight line nearly parallel with the other ridges through this and Oliver township, enters Centre and forms the crest of the ridge on the road from New Bloomfield to Newport 400 feet above the Juniata, and continuing about a mile further runs out behind the school-house near Mr. Oliver Rice's. It must be borne in mind, however, that although the Oriskany runs out the syncline of which it is the middle continues along the valley to a distance that cannot be well determined, but probably as far as Bloomfield.

This is by far the most important of all the Oriskany sandstone ridges in the township, in consequence of the quantity of iron ore which it contains. As it approaches the line of Oliver township the syncline, at first simple, becomes double by the rise of a small anticline in the middle of it. This double syncline begins to develop its mineral wealth in Miller township. The whole space between the sandstone walls is filled with a mass of ore and ore clay, lying in almost vertical beds and very much mixed up

together. Immense quantities of ore have been taken from this bank and sent to the Marshall furnace at Newport. For further details see the chapter on the iron ores of Perry county.

A *fourth outcrop* of the Oriskany sandstone may be traced in Miller township. It is like the last mentioned, a narrow syncline running inside the main anticline of the township. It begins to be distinct near the southern angle of the Bloomfield-Baileysburg road, and forms a more or less distinct line of outcrop for two or three miles, passing south of the Clouser Iron Ore works along the slope of the hill and gradually disappearing to the westward.

A *fifth outcrop* occurs in the south and runs for more than a mile along the north foot of Dick's hill between the limestone and the shale. It is brought out by the Perry county fault which here throws the Lower Helderberg limestone against the Chemung. The fault may be well seen on the township line at Montebello narrows, where its throw is nearly or quite at a maximum amounting to 5000 feet.

The Marcellus limestone, ore and black shale, and Lower Hamilton rocks, (VIII.)

No very extensive exposures of these beds are found in the township but there is sufficient evidence of their existence. At the north end of Pine Grove narrows a great quantity of loose blocks of the Marcellus limestone may be seen. They have been thrown out in searching the ground for the Marcellus hematite bed, but as the openings have long fallen in, no details can be obtained concerning their thickness. The Marcellus shale has been taken out from the same opening and heaps of it lie on the ground.

Some of these beds may also be seen at Montebello narrows where they are slightly overturned and have a dip of 95° south-southeast. The Marcellus shale is well shown. A bed of hard close-grained sandstone here lies at the base of the Marcellus. It is about a foot in thickness and has not been observed elsewhere in the county.

Enough has already been said concerning the Marcellus

ore in the report on the ores of the county, and in the report on Oliver township.

The Hamilton sandstone, (VIII.)

Four lines of Hamilton sandstone cross Miller township from east-northeast to west-southwest. Three of them form high bold rough ridges. The other is here low but rises into the third summit of Half Falls mountain in Watts township, immediately after crossing the Juniata.

The *Buffalo hills* make the northernmost of these ridges. It enters from Oliver and runs through the township in a straight line to Baileysburg where it crosses the Juniata. Its heavy solid beds, almost vertical, may be seen by the side of the railway which runs parallel with them for half a mile or more south of the station. The northern slope of this range is gentle and has been cleared along part of its course almost to the summit, but there are few more barren, rough and forbidding hillsides in Perry county, perhaps none, than the scarped and stony, steep, southern front of Buffalo hills overlooking Bailey's run. Few trees can get a hold upon it and the attempt to scale it is most likely to start an avalanche of loose blocks. The run which has here cut a deep valley out of the rocks lying between the Oriskany and Hamilton sandstones has excavated a channel for itself across the latter which forms a picturesque conclusion to the long valley above it. The road leading down to the Juniata affords one of the most beautiful drives in the county for rock and woodland scenery; and the river valley, though on a larger scale, is here scarcely less beautiful, being hemmed in between the termination of Limestone Ridge, Mahanoy ridge, and Buffalo hills on the right bank and the three bold headlands of Half Falls mountain on the left. The ledges of Hamilton sandstone crossing the Juniata here form a rapid, the incessant murmur of which adds the pleasure of the ear to that of the eye. Altogether the gap of the Juniata between Miller township on the one side, and Howe, Buffalo and Watts on the other, is, perhaps, the most beautiful piece of near scenery in Perry county.

It has not the distance that forms so great a charm in the landscape at Duncannon and Liverpool, but the beauty, though of a different cast, is in no degree inferior.

Mahanoy ridge, the description of which has been in part anticipated by the account of the second line of Hamilton sandstone outcrop, contributes much to the beauty of landscape, forming as it does in Watts township the middle and highest peak of Half Falls mountain. Entering the township from Centre it passes a little south of Pine Grove, which in height is less than usual, and Pine Grove narrows, consequently, are less picturesque than most of the passes through this sandstone. Ranging from this point eastward to the river, and almost uniformly high, it affords no other pass practicable for a road, but forms a southern wall to the little narrow valley, of which the ridge previously described, is the northern barrier. The drainage of this valley is divided between the brook falling into the Juniata at Baileysburg, and another reaching it about a mile and a half to the southward. No gap exists through this hill in the township except that already mentioned at Pine Grove Narrows.

The third (Dick's hill) range of Hamilton sandstone is, in this township, insignificant, but not, therefore, undeserving of notice, because in Watts township it rises in a bold ridge. The origin of this ridge is connected with the formation of the *Perry County fault*, of which mention has been made in the description of the county, and also of Spring and Centre township. See also Watts township.

The fourth range of Hamilton sandstone in this township is the eastern end of Dick's hill, which enters from Centre at the Montebello narrows and continues nearly uniform in height until it rather suddenly declines about a mile and a half further east. This range is brought up as already explained by the great fault, the throw of which gradually increases from west to east (as shown in Chapter IV, page 85, above) to this point, from which it suddenly decreases, and Dick's hill comes to an abrupt termination about two miles west of the Juniata. The sandstone here sinks nearly or

quite out of sight and cannot be traced in the low ground intervening between it and the river. But it rises again on the other side in Watts township, and forms the fourth summit of Half Falls mountain.

So far as can be determined the whole plain across which Losh's run flows is underlaid by an exposure of the Hamilton upper shales, Genessee and Portage brought up by the double line of fault described above.

The Hamilton fossil ore. (VIII.)

A good outcrop of this ore crosses the township along the south slope of Mahanoy ridge from Pine Grove narrows to the Juniata river. It has been mined at several places and a great quantity of ore taken out. Abandoned workings may be seen along the road from Pine Grove to Losh's run, especially on the ground of Mr. G. Peterman and Mr. P. Cook. The bed of ore at the former place is said to be between two and three feet thick, and was mined for some distance under cover more than ten years ago, (written in 1883.) A considerable quantity of ore was taken out and sent to the furnace at Duncannon, but with the fall in the price of iron the mine became unrenumerative, and the two drifts are now wholly or partly fallen in. The difference in quality between the two parts of the bed at this outcrop is well shown by the following analyses made by Mr. A. S. McCreath:

	<i>Sesquioxide of iron.</i>	<i>Alumina.</i>	<i>Siliceous matter.</i>
Top bed of ore,	44.1	9.3	34.0
Middle division,	33.4	12.1	44.6
Bottom (fossil) layer, . . .	40.7	3.7	48.9

These figures show that the ore is a very silicious brown hematite, especially near the base. This might be expected from its proximity to the sandrock. As a whole it yielded about 27 per cent. of metallic iron.

The usual fossil of the ore bed and *Paracycles* shale may be found on the spoil-bank, but greatly damaged by long exposure to weather.

The Hamilton Upper shale, (VIII.)

Four lines of this shale cross the township. The first is on the north side of Buffalo hills, and nearly coincides with the upper road from Newport to Baileysburg. No good exposure occurs along it, but its presence is indicated in several places in the fields.

The second line is on the south side of Mahanoy ridge from Pine Grove Narrows to the Juniata river. This line of outcrop may be seen in the roadside near Peterman's Ore works, where the characteristic fossils of the *Tropidoleptus* shale may be collected.

At Peterman's and Cook's ore banks the characteristic fossils of the *Paracycles* shale may be found. This line of outcrop bends more to the south, thrown over by the rising of the second ridge of Hamilton sandstone. The end of Mahanoy ridge is doubled by a fault which develops itself near the Juniata on the west bank, and increasing in throw as it approaches the river brings up the Hamilton sandstone which is shown at the canal lock. The *Tropidoleptus* shales may be seen about a quarter of a mile from Losh's Run station, where they yield their usual fossils. This outcrop seems to extend far enough to the south to meet that brought up by the Perry county fault, so that there is here a doubling at least of the Hamilton Upper shales.

There is a probability that a narrow strip of newer rocks may run along the middle of the valley and part these two upthrows, but I have seen no trace of it. Most of the ground is covered with alluvial deposit, and consequently the determination is very difficult and would require much time.

The position of these confluent outcrops of the Hamilton Upper shale may readily be seen by looking at the geological map of Miller township.

The Genessee, Portage, Chemung group, (VIII.)

The rocks of this group compose almost the whole peninsula of which the northern part of Miller township consists.

It is surrounded on three sides by the Juniata river which cuts across these beds three times in six miles between Baileysburg and Newport. The exposure along the railway is so weathered and overgrown that little work in palæontology can be done there.

The lower and softer beds, representing the Portage and Genessee, range along the north side of the upper road to Baileysburg and are marked by low ground. The Upper or Middle ridge group (for the most part) forms the high bluffs along the river side. A good exposure occurs along the road just mentioned which crosses the beds nearly at right angles.

The northern part of this group in the peninsula lies low, having been cut down by the river, and a broad expanse of flat land occupies the whole bend. The dip of the beds is almost everywhere steep to the N. N. W., but at some places, for instance about a mile south of Newport, are several small anticlines or folds.

A second line of outcrop of the Portage-Chemung group in Miller township lies to the south of Mahanoy ridge on the south slope of the Hamilton upper shales. The lower softer beds here also form a valley which is drained by the north branch of Losh's run. The harder layers of the Upper Chemung group form a rough, wooded range of low hills skirting the north slope of Dick's hill and abutting on the limestone and the Hamilton sandstone brought up by the fault. This outcrop shows a S. S. E. dip almost everywhere.

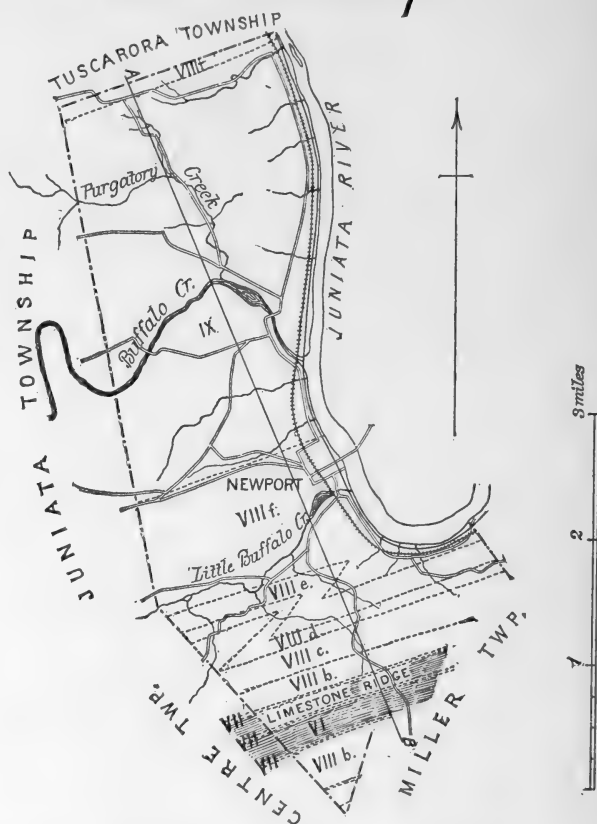
The tract of Portage-Chemung here described narrows down eastward owing to the protrusion southward of the Upper Hamilton shales brought up by the small fault in Mahanoy ridge near the Juniata, as shown on the map. It is finally thrown out altogether before reaching the river by the meeting of this outcrop of Hamilton upper shale with that brought up by the Perry county fault along the line of Dick's hill.

The Catskill group, No. IX.

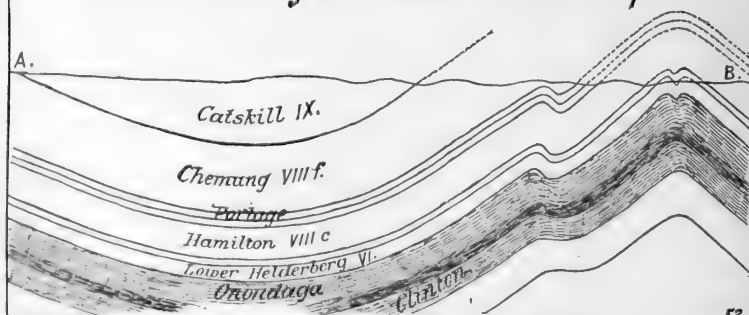
A small area of these rocks exists at the northern point

of the peninsula. But it is overlain by alluvial deposit and cannot be seen. Should the Juniata continue cutting its channel northward at this point as it is now doing the time will come when there may be found in Miller township a considerable extent of Catskill rocks that now lies under the water of the river.

Oliver township.



Section along the line AB on map.



11. Oliver township.

This, one of the smallest townships in the county, contains the largest town, Newport.

It borders on the Juniata river for about 6 miles from the southern line of Tuscarora township to the great bend between Newport and Baileysburg. It is bounded on the west by Juniata and Centre township and on the south by Miller, and its entire area does not much exceed 20 square miles.

Excepting the margin of the river where some flat and alluvial land occurs, the whole surface of the township is hilly and much of it wooded. No heavy timber exists, the demands of the charcoal furnaces in years past having caused its destruction. Since, however, they went out of blast a young growth of wood, chiefly chestnut, has sprung up and covered the hillsides where the plow does not visit them.

The principal ridges in this township are in the south.

Limestone ridge, extending from Centre township, passes through its southern angle and affords the only supply of limestone of any value that is contained within its limits.

The Buffalo hills run parallel to and a short distance north of Limestone ridge. They are not continuous but broken by deep passes or gaps. There is consequently no gathering ground of sufficient extent to produce a considerable stream. All the runs that issue from the springs among these hills find their way through one or another of these gaps into the basin on the north side of the range. This basin is bounded on the north by Middle ridge, which differs from most of the ridges in being completely cleared and cultivated to its very top. A road runs west-southwest from Newport along its summit giving a wide view over the adjacent country.

Middle ridge and *Limestone ridge* form the northern and southern boundaries respectively of the basin of the Little Buffalo creek which falls into the Juniata at Newport, and is there used to supply ice and mill power. The largest stream in the township is the Buffalo, which occupies the wider valley or basin between Middle ridge and Hominy ridge in Tuscarora township. Its course is much more sinuous in consequence of the greater breadth and flatness of its basin, and it enters the Juniata about two miles north of Newport.

In the northern part of the township the western bank of the river is fenced by high cliffs close to the water, while the bank on the other side is comparatively low. The reverse is the case just above Newport. The waters of Cocalamus, entering below Millerstown, may have aided in eroding the land about its mouth, and those of the Great Buffalo may have done the same near Newport. Both streams once flowed at a much higher level than they do at present.

The Lower Helderberg group, No. VI.

This is the lowest bed cropping out in Oliver township, and forms only two narrow lines across its southern end. Their structure will be at once understood by examining the map and sections of the township given herewith. They are two anticlinal ridges extending east from Centre township. The shales of the Onondaga group sink beneath the surface near the line, and the limestone on the northern side dips off their slope, rising again immediately and emerging at the surface, when it forms a very narrow outcrop before it again sinks under the Buffalo hills.

The Oriskany sandstone (No. VII) outcrops cross the southern part of the township.

The Marcellus group, (VIII.)

This group is commercially the most important in Oliver township because it contains the unusually rich deposit of hematite which has been worked for many years to supply the blast furnace at Newport. The structure of the rocks

here has been fully explained in the chapter on the iron ores of the county, Chapter IV, page 91, above. It is sufficient to remark that the ore occurs as usual in a thick mass of white and black clay, occupying the place and perhaps produced by the decay of the Marcellus limestone. These ore works are more advantageously situated than any others in the county that mine this bed. The distance to the furnace is less than two miles, all down hill. Water is sufficient for washing the ore and its extraction is easy. The beds lie nearly vertical and the material is soft. The quantity, however, to be washed is very large as the ore is much scattered through the body of the clay, which is in some places 15 or 20 feet in thickness.

The black shale is seen in but few places, and presents no unusual feature.

The Hamilton lower shale beds form a long narrow valley on the south side of the Buffalo hills extending across the township. It is not cleared and needs no notice.

The Hamilton sandstone, (VIII.)

The Hamilton sandstone of Buffalo hills forms the only rugged ridge in Oliver township, though that portion of Middle ridge near Newport composed of the Chemung upper shale makes a very near approach to it in steepness and roughness. The Hamilton sandstone enters the township from Miller at the east and runs W. S. W. across the road from Newport to Duncannon, where it crops out at the edge of the wood. It crosses the township line in the narrows and then returns, being thrown out by one of the northern anticlines of Limestone ridge, reenters the township, and again zigzagging westward passes out finally at the lower end of the narrows where it is cut through by Inoculate run. There are no features calling for remarks in this short line. The sandstone shows the same characters as in Centre township, in the account of which full details concerning it may be found. Its dip is very steep, about 75° N. N. W. toward the southeast line, but it flattens down towards Inoculate run to 25° or 30°. The steeper dip may be seen between Newport and the Clouser Iron Works at the top

of Limestone ridge where the road passes through or rather over the Hamilton sandstone. The channel of the brook can scarcely be called a gap, rising as it does to summit level where the water, before it begins its journey down the hill, is employed in washing the ore.

The Hamilton fossil ore.

This belt of iron ore runs through the township immediately north of the Hamilton sandstone but I am not aware that any has ever been taken out along its line of outcrop, which is very near the edge of the woods for the most part though in some places toward the eastern end it lies well up in the wood. Its place may be found on the map by marking the top of the Hamilton sandstone.

Several attempts have been made to open the bed but little more has been done than to prove its presence along the north side of the hill. It is certainly very thin in most places and the probability is that if opened it would prove lean and sandy.

The Hamilton Upper shale.

This band of shale crosses the township parallel to the Hamilton sandstone. It crops out in the side of the road leading from Newport to Duncannon, about one hundred yards south of Mr. Ramer's house, and zigzagging like the sandstone crosses the township line in the fields east of the lower end of the narrows. It may be seen in Centre township on the Newport-New Bloomfield road near the top of the hill rising from Inoculate run where it is very calcareous. The characteristic fossils of the Fenestella shale may be found abundantly at both these outcrops.

The Genessee shale, (VIII.)

The 200 feet of barren, whitening shale which I have considered to represent the Genessee of New York may be found in their proper place between the Hamilton Upper shale and the Portage shale. They crop out at the roadside immediately over the Hamilton Upper shale.

The Portage group, (VIII.)

There are two good exposures of the *Cardiola shale* of this group in Oliver township on the two roads leading south from Newport. On the road to the Clouser Iron Ore Works it may be found on the hill north of Mr. Ramer's house where most of the characteristic species may be obtained. Another outcrop, where only the Portage-Chemung sandstone and the topmost beds of the Portage are exposed, is on the upper road to Baileysburg on the land of Mr. Longacre.

The Chemung rocks, (VIII.)

Two short outcrops of these rocks cross the township, one in the north and another in the south. The former is merely the margin of the line of outcrop that crosses Tuscarora township and scarcely needs mention here. The latter forms a very conspicuous object in the landscape. Its eastern bluff overlooks Newport and forms a shelter from west and northwest winds. It is a rough wooded ridge washed on its southern face by the Little Buffalo which has excavated a deep valley for itself in the soft material lying between the Buffalo hills and Middle ridge. Once this ridge was continuous with the hills on the eastern bank, but the Juniata river has cut for itself a channel through the range. It has been gradually working its way southeastward at this point, and consequently the slope and flood-plain is on the northwestern bank, while the southeastern consists of hard rocks washed at their feet by the river, and from which the water and the ice are yearly carrying away their tribute towards the sea.

Middle ridge above mentioned overlooking Newport consists in part of the hard and sandy Upper Chemung beds. These in the north of Perry county are sufficiently hard to form rough and wooded hills only inferior to those made by the Hamilton sandstone. I have consequently in some places used the term "Middle Ridge rocks" as a synonym for the Upper Chemung.

Chemung-Catskill and Catskill, (No. IX.)

The middle portion of Oliver township consists of a broad exposure of the rocks of the Catskill group formed by the union of the two outcrops on the north and south sides of Buffalo and Berry's mountains, which meet at the west end of the mountain and run out into Juniata township as a broad open canoe-shaped trough rising into the air near the township line. Along this wide open outcrop the Buffalo winds along sometimes between low banks and at others washing the feet of steep rugged cliffs as at the loop below Milford. The beds of this formation are well exposed along the bank of the river in the cuttings of the railway. The hard sandstone beds of the lower part of the formation extend southward from Rope ferry at the northern side of the trough, but are less prominent at their southern outcrop, possibly in consequence of the inflow of the Buffalo.

The rocks of this group form as usual a rolling landscape well suited for farm purposes, and with a fertile soil.

12. Penn township.

The shape of the township is rudely triangular, with its apex to the west about five miles distant from the river. The measurements, however, would give no clue to its area, which may be set down at about 18 square miles.

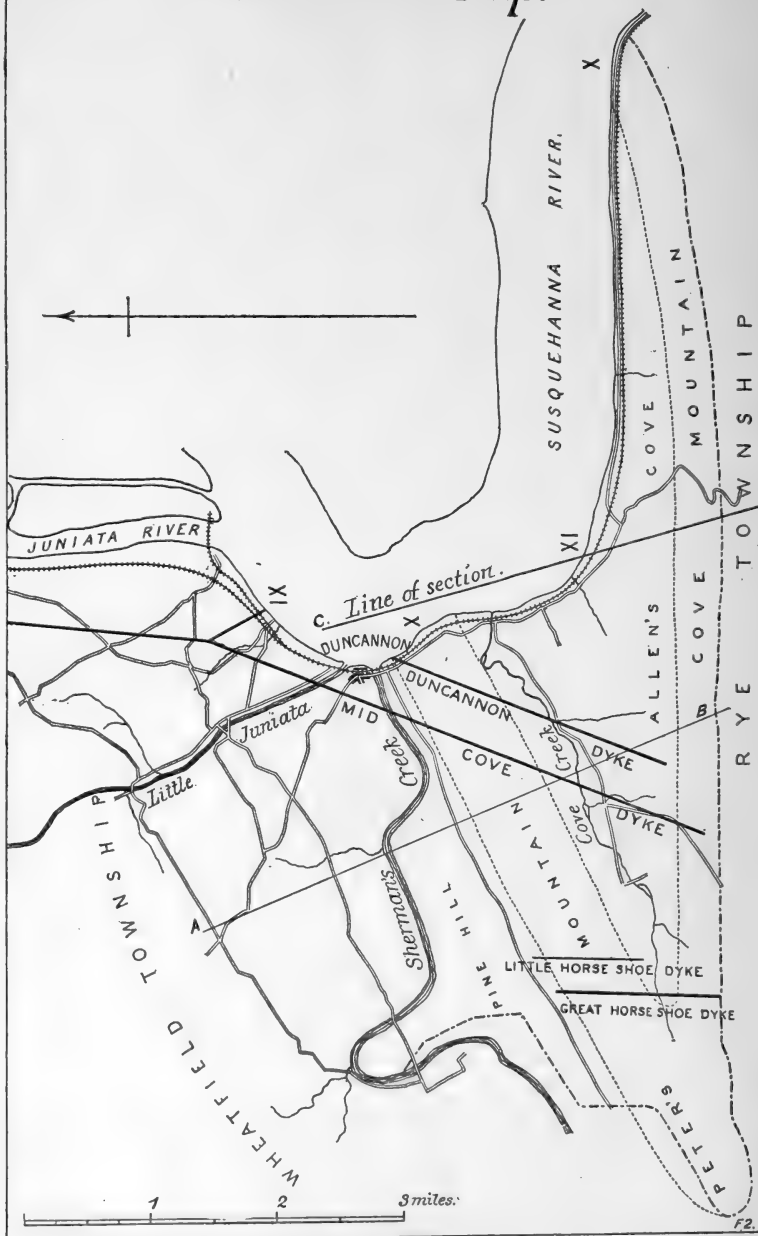
The physical features of Penn township are entirely due to the presence and direction of the Pocono Sandstone mountain. Entering it from Dauphin county, which it crosses under the name of Peter's or Fourth mountain, it runs to the southwest then curves around and turning eastward at the Horseshoe returns to the Susquehanna river, which it crosses passing again into Dauphin county. It is in fact the western extremity of the southern angle of the great Pottsville coal basin which divides at its western end something like the tail of a fish. The northern extremity lies in Buffalo township.

The outer slopes of the Cove mountain throw all the waters coming from the west outside the township.

Sherman's creek is thus compelled to skirt the northern face of the mountain until it reaches the Susquehanna below Duncannon.

Fishing creek, in the same manner, is compelled to flow along the southern face. The district enclosed by the mountain is drained by a small stream rising at the Horse Shoe bend and receiving the waters from both slopes. This district is peculiarly isolated from the rest of the county by its physical conformation. Surrounded on two sides by the mountain and on the third by the river, access to it is very difficult. Two roads zigzag across the range to the south from Rye township, and one enters from the north through the gap of the Susquehanna and passes out at the south by the same outlet. The Pennsylvania railway has taken advantage of the same natural pathway to enter and

Penn township.



leave the valley. These excepted, there is no practicable road from the outside world into this secluded district, which is, as it were, a little world by itself.

Cove mountain and *Peters' mountain* are formed by the outcropping edges of the Pocono sandstone above mentioned which descends on the north and passing under the red shale at a depth of about 1000 feet rises again to the south. The beds of sandstone in the northern side of the syncline dip sharply to the southeast, in the southern side they are nearly vertical, and at the eastern end of the range are overthrown so as to dip at 5° to 10° to the south. The sandstone is about 2000 feet thick, and owing to this and its great hardness the mountains composed of it take rank among the first in the county, rivaling those formed by the Medina and Oneida sandstones.

The slopes of the mountain are steep and wooded on both sides, and for the most part covered with the wreckage of the sandstone which is especially abundant and heavy near the Susquehanna gap.

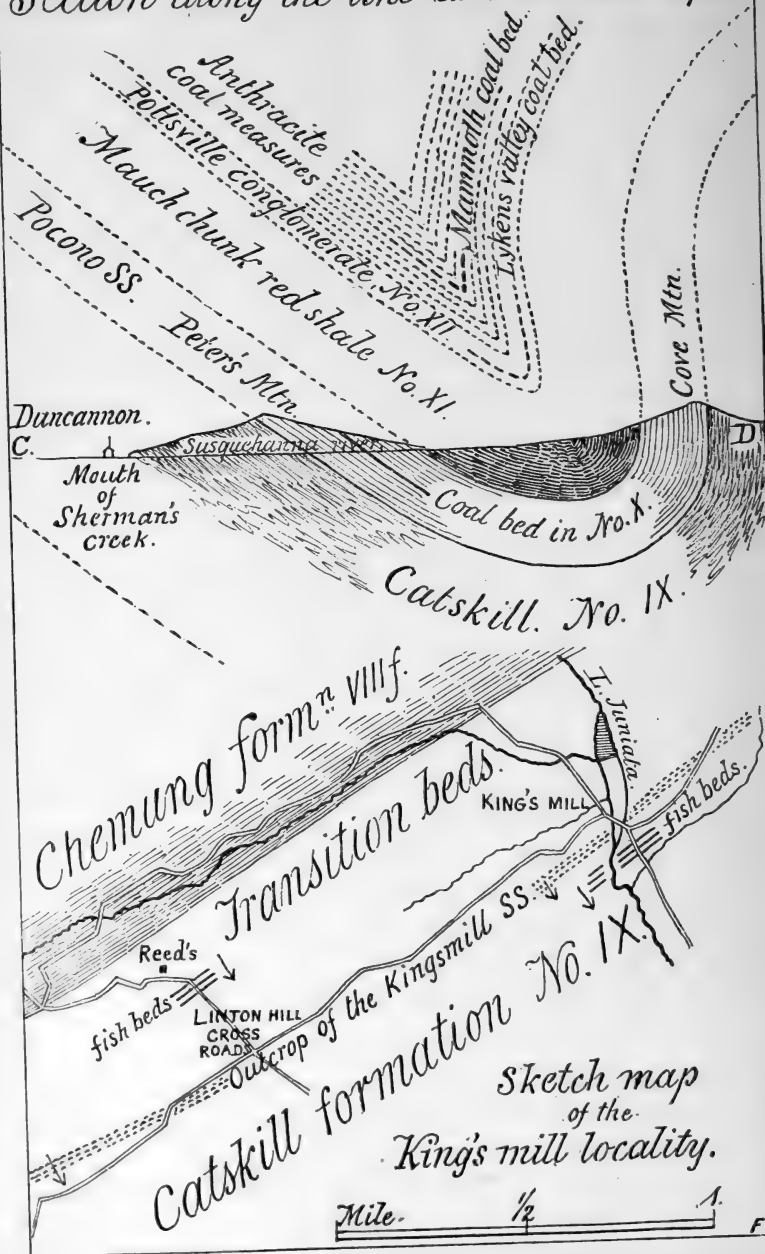
The Chemung-Catskill, and Catskill, No. IX.

The northern portion of Penn township consists of the Catskill sandstone dipping for the most part to the southeast but containing several indistinct folds which run in from the opposite side of the river. The area of red rocks exposed in the township is consequently very large and their thickness amounts to about 6000 feet.

The Catskill rocks here resemble those in other parts of the county, as described in the general report. The lower portions or passage beds have proved, however, more interesting than at any other similar exposure. Here occurs the richly fossiliferous horizon which has yielded the fossils of which an account may be found in the volume on the palæontology and the stratigraphical details of which are given below.

The base of the Chemung-Catskill rocks lies in Wheatfield township, and the line separating it from the Chemung may be drawn more or less indistinctly across from the Juniata river about half a mile south of Losh's run to the

Section along the line C-D. Penn tnp.



Little Juniata about half a mile north of King's mill and thence in the same direction southwestward, but it nowhere enters Penn township. The lowest fossiliferous layer in the group now under consideration which is found in the township is the remarkable Kingsmill sandstone of this report, which crosses near the northern line and is well exposed between King's mill and Linton's hill. The sections given herewith are found in the northern part of the township and must be considered together though the former really belongs to Wheatfield township. It is, however, placed here to avoid the separation of what are in reality only the lower and upper parts of the same section. This is the only instance I have met with of fossiliferous shales and limestones above the Kingsmill sandstone or base of the true Catskill. This exposure is only made by the recent cutting of a new road and possibly had a similar opportunity existed elsewhere similar beds might have been displayed.

All the beds of the Linton's Hill section (see page 290) lie beneath those of the Kingsmill section described below, on page 289.

The peculiar sandstone bed with its crowded Lamellibranch casts at the top of the Linton's Hill section appears near King's mill, and is there evidently many feet below the base of the Kingsmill section, probably 200 to 300 feet below it. By combining the two sections and including the space between them (200 ? feet,) the space between the base of the lower section and the lowest layers of the Chemung-Catskill (50 feet ?) and the space to the thin coal seam in the Dellville sandstone lying above the top of the higher section, (about 80 feet,) we obtain a section of the Lower Catskill and Chemung-Catskill rocks about 1300 feet.

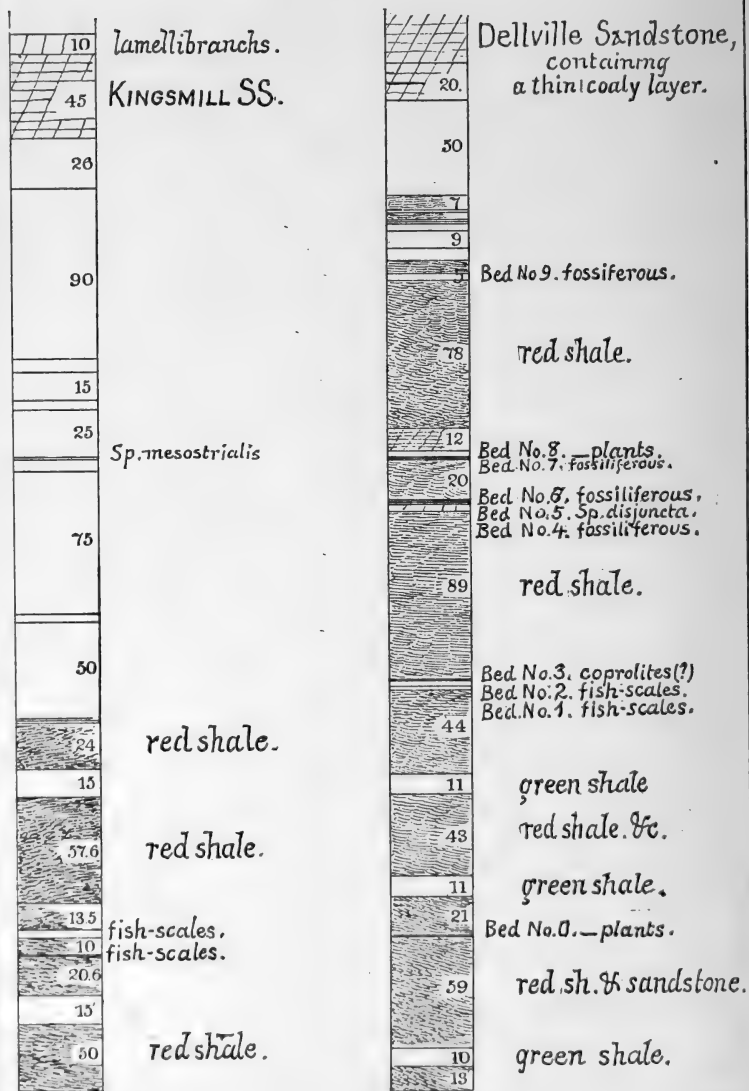
The Kingsmill section.

The following beds are exposed by a side cutting on a road running nearly N. W. and S. E. made about twelve months ago, and on the N. E. side of the road. At the S. E. end or top of the section, where the cutting begins, near the little run, the rocks dip 40° S. 20° E.:

Catskill-Chemung. Catskill.

Linton's Hill section

Kingsmill section.



Kingsmill section, (Lower Catskill, IX.)

Dellville green sandstone with thin coaly layer,	20' 6"
Space concealed,	50' 0"
Red shale and sandstone,	7' 0"
Green shale, no fossils seen,	1' 9"
Red sandstone and shale,	3' 6"
Green shale,	1' 0"
Red sandstone,	1' 0"
Green shale,	4' 6"
Red shalestone,	0' 6"
Green sandstone,	9' 0"
No. 9. Green shale, <i>fossils seen</i> ,	5' 0"
Red sandstone and shale,	7' 6"
Green shale,	4' 0"
Red shales with a thin green bed,	78' 0"
Red sandstone in thin beds,	12' 0"
No. 8. Green sandstone, hard, thin bedded,	2' 6"
" " <i>with plants</i> ,	0' 6"
Green sandy shales.	
Red shale,	0' 8"
No. 7. Greenish yellow shales, <i>fossils</i> ,	2' 6"
Red shales,	20' 0"
No. 6. Green shales, <i>fossils</i> ,	0' 5"
No. 5. Bluish limestone shales, <i>fossils</i> , (<i>Spirifer disjuncta</i>),	0' 2"
No. 4. Bluish limestone, <i>fossils</i> ,	0' 5"
Green sandy bed,	0' 5"
Red sandstone with some red shale marked with green spots and blotches.	
Solid red sandstone,	4' 0"
Red shales and thin red shalestones with some thin slightly micaceous sandstones,	89' 0"
No. 3. Coprolite (?) bed, green sandstone,	0' 3"
Red sandstone,	3' 0"
No. 2. Thin bed, (fish scales,) Fish bed.	
Micaceous red sandstone,	2' 0"
No. 1. Thin bed with fish scales.	
Red shales and shalestones,	44' 0"
Dip 35° S. 30° E.	
Green shales,	11' 0"
Red shales and shalestones with some green beds,	43' 0"
Green sandy shales,	11' 0"
Red shale and shalestone,	21' 0"
No. 0. Yellow sandy bed <i>with plants</i> ,	0' 6"
Red shales and shalestones,	59' 0"
Green shalestone,	10' 0"
Base. Red sandy shalestones and shale with thin solid beds,	13' 0"
Dip S. 20° E.	553' 0"

Linton's Hill section, (Catskill-Chemung.)

(Along the road between Mr. Reed's house and the cross-roads, and one mile west of King's mill.)

Solid white and yellow sandstone, (exposed almost at the cross-roads,) partly soft and crumbling, partly hard and like quartzite. In this bed are layers of casts of fossil lamellibranchs, &c., in lenticular beds, irregular but numerous,	10' 0"
Kingsmill sandstone, brown, thin-bedded sandstone, not well shown at and near cross-roads,	45' 0"
Space covered but probably same as next below,	26' 0"
Yellow shale with thin brown sandstone,	90' 0"
Green shale weathering yellow,	7' 6"
Brown shale,	15' 0"
Greenish yellow shale,	5' 0"
Brown shale-stone,	25' 0"
Brown rusty bed with <i>Sp. mesostrialis</i> ,	1' 0"
Brown shale-stone and shale,	6' 4"
Yellow shales? mostly covered,	75' 0"
Soft brown sandstone,	5' 0"
Yellow shale,	50' 0"
Red shale,	1' 3"
Yellow shale,	1' 3"
Red shale,	24' 0"
Yellow shale,	15' 0"
Red shales,	57' 6"
Red shale,	13' 5"
Yellowish green shales,	3' 6"
Thin red sandy shale with fish scales.	
Red shale,	10' 0"
Red shaly sandstone crossing the road in ledges and full of scales of fish,	3"
Red shale,	20' 6"
Yellow shale,	15' 0"
Red shale opposite Mr. Reed's house and about 200 feet horizontally from limit of red shales=36 feet vertically,	50' 0"
	<hr/> 557' 0"

The Kingsmill section which exhibits nearly 500 feet in vertical thickness of the Catskill group, and nine different beds containing animal fossils.

In No. 9, the uppermost, I could not obtain any, owing to the scanty material, but saw them in the rock.

In No. 7 a greenish yellow, soft shale, much weathered are numerous but indistinct small organic remains, not recognized.

No. 6 also consists of a green shale with Lamellibranch shells.

No. 5 is a thin bed of limestone weathering to a soft rusty mass and full of Brachiopods and Lamellibranchs, often in a fair state of preservation, *Sp. disjuncta* very small.

No. 4 is only a repetition of No. 5 in mineral composition, being a limestone from which the water has partly removed the lime, leaving a similar dark rusty mass. It contains immense numbers of two species of *Beyrichia*, showing white on the weathered stone, but difficult of detection in the blue limestone core.

No. 3 is a green, soft, sandy shale rubbly in texture and containing numerous small nodules or concretions, which from their appearance would be taken for phosphatic coprolites, but an examination by Mr. A. S. McCreath gave a very small proportion of phosphoric acid.

No. 2 is the Upper *Fish bed*, a thin layer on a surface of red shales composed of the scales of *Holoptychius?* and *Bothriolepis*. These two are probably one species of *Holoptychius*.

No. 1, about 2 feet below No. 2, consists of similar material with the same remains.

Two beds containing plants occur in the section. One near the base of the section shows the usual "plant rags" occurring in so many horizons in the Devonian here. Another near the top of the section shows similar remains.

The Kingsmill sandstone consists of a white or yellowish sandstone perfectly honeycombed with casts of Lamellibranch shells, among which *Schizodus rhombeus*, Hall, is the most abundant. It has accumulated here in immense numbers, washed up on the beach or on a sand-bar in the ancient ocean. They were evidently dead and drifted shells for I have never seen two valves together or in their natural position.

The stony ridge, formed by the outcrop of the Kingsmill sandstone wherever it occurs or can be traced in the county, continues west and east from this point. It reappears on Mr. G. Brunner's land also about a mile to the eastward, and passes very near the head of the great loop on Sherman's

creek. It continues into Carroll township, in the report on which and in the general account of the county will be found more details on this interesting stratum.

The Pocono sandstone, No. X.

The outcrop of this hard and massive sandstone forms a rampart around the cove, about 1000 feet high, with a level and unbroken crest; sweeping from near Duncannon first southwest for four miles; then turning and running in a straight line back eight miles to the Susquehanna.

This *Horse Shoe Bend*, as it is called, affords one of the most beautiful views in the county, the mountains clad with wood from base to summit forming a green background to the river scenery.

Pocono sandstone coal bed at Duncannon.

About six years ago a tunnel was driven about 200 feet into the cove mountain by Mr. John Foose of Duncannon directly across the strata, here dipping steeply southward.

At about 150 feet from the entrance a bed of shale was cut about ten feet thick, containing two seams of coal—the upper about ten inches, the lower about thirty inches thick—separated by two feet of black shale. Two feet of black shale covered the upper coal.

The coal occurs in small pieces and is much crushed and slickensided. It would, I think, come out in pieces seldom exceeding a pound or two in weight. A specimen from this seam or from another to be noticed below was analysed at Harrisburg some years ago by Mr. A. S. McCreath, with the following results:

Volatile matter,	14.38
Fixed carbon,	48.28
Sulphur, . . . . .	.32
Ash,	36.44

It is easy to see from the high proportion of ash that the coal is of very low grade. I add for comparison an analysis of the Lykens Valley coal made by the same chemist:

Volatile matter,	8.83
Fixed carbon,	78.83
Sulphur, . . . . .	.67
Ash,	9.39

Nothing further need be said concerning this coal. The facts speak for themselves. Nor is there any probability that results appreciably different would be yielded by the other two seams which accompany this and may, like it, be traced along the mountain by the slight terraces at their outcrops.

The Mauch Chunk red shale, No. XI.

This red shale occupies the whole trough or basin of the cove. Its beds dip regularly from the mountain on both sides, and become nearly horizontal along the middle line of the syncline. Its decay affords good farming land, and the cove, sheltered as it is from winds by the mountain ranges which almost surround it, is one of the best farming districts in the county.

Some of the beds of the Mauch Chunk red shale are calcareous enough to render the water hard.

Iron ore.

A thin bed of poor nodular iron ore accompanies one of the coaly layers in the Pocono sandstone. Specimens of the nodules have been analysed, and the percentage of phosphorus is so high as to suggest a coprolitic origin.

The great weight and yellow rusty color of the fragments of rock (*dolerite*) along the lines of the trap-dykes (described below) have deceived people into believing that they were masses of iron ore, and attempts have even been made to open mines upon the trap. But, of course, the material was rejected by iron-makers. Trap is not iron ore, although grains of magnetic iron are scattered through it.

The trap-dykes of the Cove.

Trap-dykes are ancient cracks in the earth filled from below by lava which has hardened into rock. They must be

of great depth, for they can be traced along the present surface of the earth for a great distance. The trap-dyke described by Dr. Frazer, in his report on Lancaster county, runs in a nearly straight line (N. E.) forty miles. Many others exist in Adams, York, Lancaster, Dauphin, Lebanon, Berks, Chester, Delaware, Montgomery, and Bucks counties, and in middle and northern New Jersey, southern New York, and New England.

The most remarkable of them all starts in the South Mountains, and runs in a nearly straight line across Cumberland county (between Mechanicsburg and Carlisle) to the Perry county line, on the crest of the Blue mountain, two miles east of Sterritt's gap.*

The description of the dyke, on page 366, of Vol. I of this "Geology of Pennsylvania," is erroneous in several important particulars. It reads as follows:—

"This dyke crosses Cumberland valley and cuts through the Blue mountains 2 miles east of Sterrett's gap. It crosses Fishing Creek valley and the Cove mountain bearing N. 10° E., where it forms a low ridge separating the waters of Fishing creek from those of Sherman's creek.

"The dyke next crosses the Cove where its loose fragments are strewed over the surface to a great extent. The point where the dyke cuts the northern ridge of Cove mountain is not visible but we find the mass $\frac{3}{4}$ mile north of Petersburg, (Duncannon,) where, with a bearing of N.

* Dr. A. A. Henderson, assistant geologist on the first survey, in 1849, supposed that the dyke here entering his district extended to the Juniata and beyond the Susquehanna into Dauphin county, 30 miles from its southern end at the Boiling Spring, on the Yellow Breeches creek, in Cumberland county. This is evidently not the real southern end of this dyke. It undoubtedly continues southward through the South Mountain rocks into York county, and joins the trap-dykes north of Petersburg, for Mr. A. E. Lehman, assistant geologist on the second survey, has found traces of it in the wooded parts of the mountain.

It is but justice to Dr. Henderson, who was one of the best geologists of his day, and to whom we owe our first accurate knowledge of the complicated structure of Perry, Juniata and Mifflin counties, to say that he could only with great difficulty at that early day trace the line of the dyke upon his map; and the line which he laid down on his map was transferred to the Geological Map of Pennsylvania, made by me in 1842, and published by Professor Rogers in the Atlas to his Final Report, in 1858. [J. P. L.]

30° E., we trace it for many miles. It reaches the Juniata $1\frac{1}{4}$ miles above the head of Duncan's island where it can be seen well exposed on the turnpike. From the Juniata it is traceable to the Susquehanna where it appears immediately below Montgomery's Ferry. It cuts the Half Falls mountain a mile from its northeast extremity.

"Where the trap-rock comes in contact with red shale the shale is indurated and altered to a dark brown and purplish color.

"The surface of the dyke is from 60 to 120 feet wide, though the actual thickness of the intrusive wall of rock beneath the surface is probably much less."

"From the Blue mountain to the point where it reaches the Susquehanna its length is 15 miles, but it crosses the river and passes into Lykens valley."

In Cumberland county there is in fact but one dyke crossing the Great valley; and this dyke is so conspicuous a landmark that it has been adopted as the boundary line between four townships: Silver Spring and Monroe on the eastern, and Middlesex and South Middleton on the western side of it.

But in Perry county the crust of the globe was cracked not merely along one line, as the old map represents it, but along several lines, each of which produced a separate trap-dyke.

On the township maps of Penn (Plate XXX) and of Rye (Plate XXXIII) I have drawn the lines of four trap-dykes crossing the Cove, and its bounding mountains, one of which is much longer than the other three, and extends northward, through Wheatfield, beyond the head of Duncan's island. (See Plate XLV.)

There is another dyke in Watts (see Plate XLIV) which is almost in exact line with the course of the long dyke in Penn, before it makes its bend, a mile north of Duncannon, and this is what deceived Dr. Henderson into supposing that there was but one long dyke, the whole length of 30 miles.

I shall describe the four dykes in Perry county under four special names:

(1.) The Great Horseshoe dyke, Ironstone ridge, or Cumberland county dyke.

(2.) The Little Horseshoe dyke, next, east of, near and parallel to the great dyke.

(3.) The West Duncannon dyke; and

(4.) The East Duncannon dyke, next, east of, near and parallel to it.

The two Horseshoe dykes run south across Rye township, and will be also described in the geology of that township. The West Duncannon dyke will also be noticed in the geology of Wheatfield and Watts townships; but the East Duncannon dyke is confined to Penn township.

(1.) *The Great Horseshoe dyke, Ironstone ridge, or Cumberland Valley dyke.*

The line of this dyke may be detected by loose fragments on the south side of Peter's mountain about two and a west of the river and between the highest terrace and the summit of the mountain.

Its course is plainly indicated down the slope by the same evidence from terrace to terrace, with a bearing of S. 10° W. into the Cove at the foot of the Horseshoe and almost to the creek.

Along this part of its course it appears to be the widest of all the dykes in the Cove, but just before it reaches the creek it suddenly and markedly increases and assumes comparatively gigantic proportions, admirably displaying both the trap and the accompanying rocks altered by contact with it.

The sandy beds of the Mauch Chunk Red shales (XI.) which are here cut through are changed to a dark brown and chocolate colored material; the red shales themselves are in some places burnt into a mass resembling half made brick, but not usually much hardened. Some fine shale beds, however, have been so much changed that they are almost as tough and hard as the trap itself.

This change in the appearance of the rocks at this point has led to considerable excavation in the belief that the

dark, soft, sandy shale beds contained copper—a belief for which there is of course not the slightest foundation. But the excavation serves to make very plain the striking development of the dyke at this point. From being a dyke very much resembling the other three—perhaps rather larger—it suddenly enlarges and becomes nearly 200 feet from side to side. The bed of the Cove creek and the flat, marshy ground alongside of it, overgrown with a thicket of laurel, in some places impenetrable, is thickly bestrewn with massive blocks of the dyke up to half a ton in weight. How far this display continues through the wood I cannot say nor to what height it rises on the north flank of Cove mountain.

The bearing of this dyke is S. 10° W.

(2.) *The Little Horse Shoe dyke.*

About a quarter of a mile east of the great Horse Shoe dyke, another parallel line of fragments can be found high up the south slope of Peters' mountain, in fact upon the highest terrace.

Its first appearance, so far as I am aware, is at an old shaft sunk some years ago under the impression that the trap dyke carried an ore vein. The shaft was sunk to a depth of about 25 feet, and at the depth of about 22 feet many blocks of the hard, tough, dolerite (trap rock) were thrown out.

This is the most northerly indication of this dyke that I have seen in the cove. Hence, it may be followed at intervals, southward down the slope of Peters' mountain, forming an almost continuous line through the thickets to the cleared land in the cove below, where it crosses first a field and then the road leading west into the woods of the Horse Shoe, and is lost to view at the creek, where a large meadow is almost ruined by the number of blocks which lie scattered about upon it.

Beyond the creek no one, so far as I can learn, has succeeded in tracing it, so that it probably does not rise so high on the Cove mountain as it does on Peters' mountain.

I have no means of estimating the breadth of the dyke

but judge it not to exceed 6 or 8 feet. Its bearing is, as nearly as I could ascertain it, south 10° west.

(3.) *The West Duncannon dyke.*

Half way between the head of the cove and the river, and near the foot of Peters' mountain, a range of trap can be readily traced. It crosses Cove creek close by an old saw-mill pond, now dry, and then shows in a byway on the north side of the main turnpike road. Following it over a field it is seen very plainly in the bank, and then runs along keeping parallel with the same road as far as the foot of the Cove mountain.

In front of the farm-house which stands at this point is a well sunk exactly on the line of the dyke. Mr. J. M. White, who sank this well, informed me that he passed through the dyke, and that it is not vertical, but pitches to the west, at an angle of about 45° . The greater part of the well was sunk in the red shale, the dyke being left at a depth of about 8 feet. It measures here only about 6 or 8 feet, and consists of a number of loose blocks embedded in the red clay—the product of their own decomposition.

In the neighboring field a pit was dug to examine the dyke which gave the same results.

Crossing the road at this point the dyke can be traced about 100 yards further through the orchard into the wood where all traces of it are lost, nor has any one, to my knowledge, ever seen it higher on the hill.

(4.) *The East Duncannon dyke.*

About three quarters of a mile further east a trap-dyke may be seen in the roadside about $\frac{1}{4}$ mile south of the mouth of Sherman's creek. Thence it has been traced up the hillside, where its outcrop has been followed, in a vain search for iron ore, to the top, but not to the *crest* of the mountain. The dyke cuts through it near the brow overlooking the river.

It continues on the same course, S. 20° W., down the slope of Peters' mountain into the cove, and may be fol-

lowed by the color of the soil and the loose blocks lying about across the fields to the main road up the cove, which road it crosses just east of a farm-house.

Running on thence with the same bearing, it may be seen alongside of the road (which here turns to the south-south-west) for about 200 yards, where crosses a lane running off at the next angle in the road. Here its presence is marked by the usual red clay and boulders. Beyond this point I have not traced it.

This set of parallel dykes in the cove constitutes a distinct and interesting feature in its geology. Ranging across it from mountain to mountain, like four walls, they divide it into five separate portions, and were they all as heavy as the last mentioned, would form serious barriers to communication, and difficulties in the way of the farmer. As they are it is often a task of great labor to dig out and carry away the fragments from the fields and pile them up at the roadsides where their subangular form and rusty color make them conspicuous objects to the passer by.

They all consist of the same tough, hard dolerite, showing some but very little variation in composition and fineness at different places.

The most remarkable thing about these dykes is this:—*Not one of them has ever been detected at the top of either of the two mountains*; the East Duncannon and Great Horseshoe dykes alone rising above the highest terrace, so far as known. The West Duncannon dyke does not appear to rise into the mountain at all, its exposure ceasing sharply at the foot. It is not however impossible that further examination may modify this assertion which is based on negative evidence only.

The trap-dykes north of the Cove.

The West Duncannon dyke is the only one of the Cove dykes which exists to my knowledge north of Peters' mountain and west of the Juniata river. I can most easily describe it by beginning at its northern end.

Its first appearance is on the turnpike road about one

mile south of Losh's Run Station on the Pennsylvania railway.

Its next appearance, so far as I am aware, is on the road leading west from the Aqueduct.

There is no trouble in following it from this point by an almost uninterrupted series of exposures to Duncannon. Its course is marked by the red color of the soil, for a mile due south, across fields, to the road running west from the railway station at Juniata bridge.

Here a pit was sunk some years ago in quest of ore on the western edge of the dyke, to a depth of about 25 feet. A drift was then run for 6 feet into it in the attempt to penetrate it. This made its thickness upwards of twelve feet. The same discolored sandy shales were thrown out here as in the Cove.

At this point the direction of the dyke suddenly changes; but a thin vein of trap appears to continue nearly on its former course, as indicated by an occasional trap pebble in the low ground. Such pebbles have been found in the run close by the place where the change occurs, near the grist mill west of Duncannon, and again at a short distance behind the nail factory. These are sufficient to indicate a faint continuation of the dyke in its former direction as far as to the north foot of Peters' mountain. An examination of the map will show that it is on the line of dyke No. 3 in the Cove, before described.

But the main mass of the dyke suddenly bears away at S. 30° E. down a slope, across a field, passing under a house (as shown when the cellar was dug) and so reaching the river

It has not been seen in the bed of the river; but on the opposite or eastern river bank, opposite the mouth of Sherman's creek, and exactly on the right course, what is probably the same dyke is displayed in a cutting of the North Central railway. This exposure gives an opportunity of measuring the thickness of the dyke, which is about 50 feet. It does not appear to rise to the surface; and the rocks on both sides are altered as in the case of the Great Horseshoe dyke in the Cove.

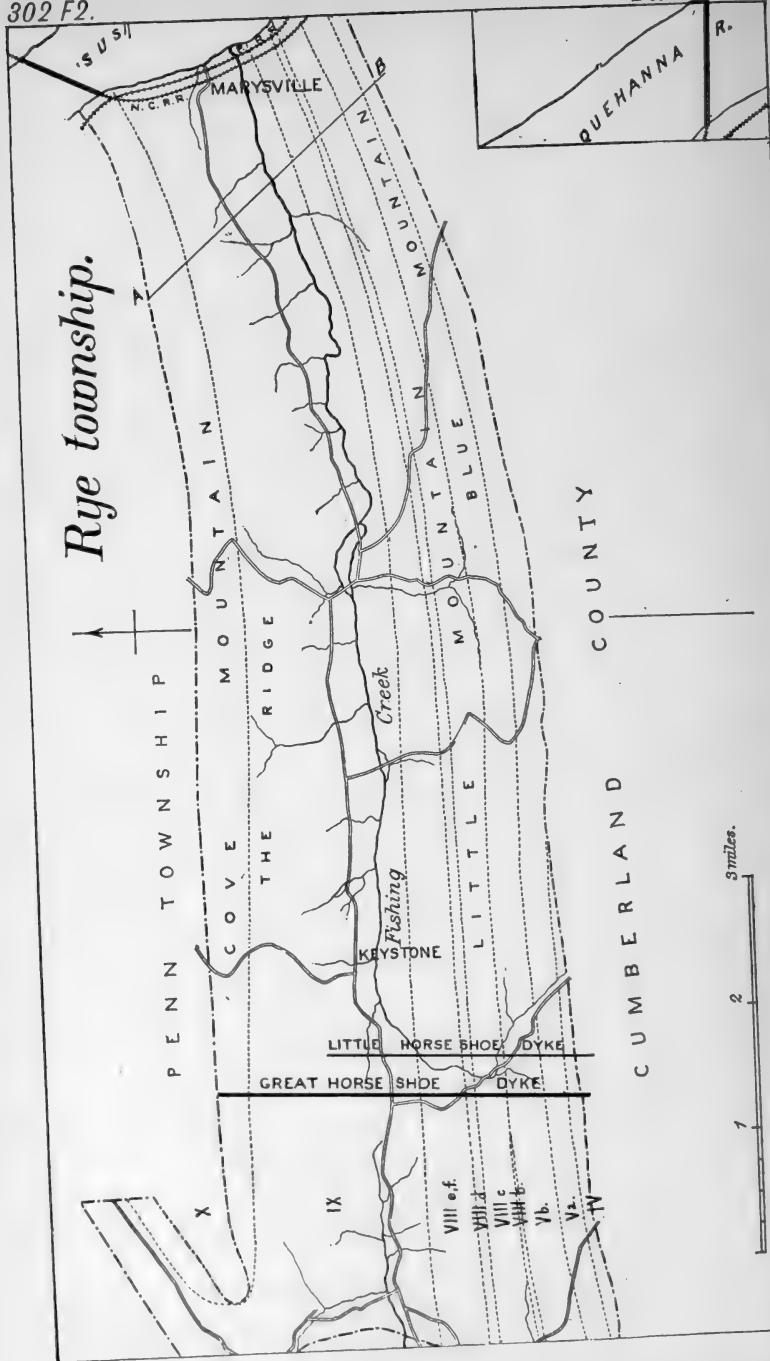
The geological age of the trap-dykes.

Not one of these dykes is yet known to appear upon the very summit of either Peters' or the Cove mountain. The great Horse Shoe dyke ranges highest, running, as has been shown, up to the topmost terrace of Peters' mountain on its southern flank. This failure of the dykes to appear at the summit proves the mountains to be older than the dykes.

Now since the Triassic red sandstone of York county is cut by numerous similar dykes with which these Perry county dykes seem to be connected, they must be not only later than the coal measures, but of later age than the Trias; but as no such dykes are known in the Cretaceous beds of the Atlantic seaboard, our dykes must be older than the Cretaceous age.

Nature of these Trap-rocks.

The trap of Perry county is a hard, very tough, dark, heavy and fine-grained *dolerite* containing grains of magnetic iron ore disseminated through the mass, readily discoverable by crushing a small piece with the hammer and applying a magnet when the magnetite immediately clings to it. The presence of this material is partly the cause of the decay which takes place at the surface of the trap. Under the action of moisture the magnetite becomes rusty and passes into brown hematite. The outer layer of stone is softened and changes color to a rusty yellow. This outside layer scales off and the process is repeated upon the new surface thus exposed. In this way from year to year a red clay soil is produced, by the disintegration of the other materials of the rock, felspar and hornblende, colored by the iron oxide. In consequence of the abundance of this red clay along the course of the trap it is usually called by the residents of the neighborhood "iron ore," or "magnetic ore rock." But it is not likely that any merchantable iron ore will be found along the lines of these dykes.



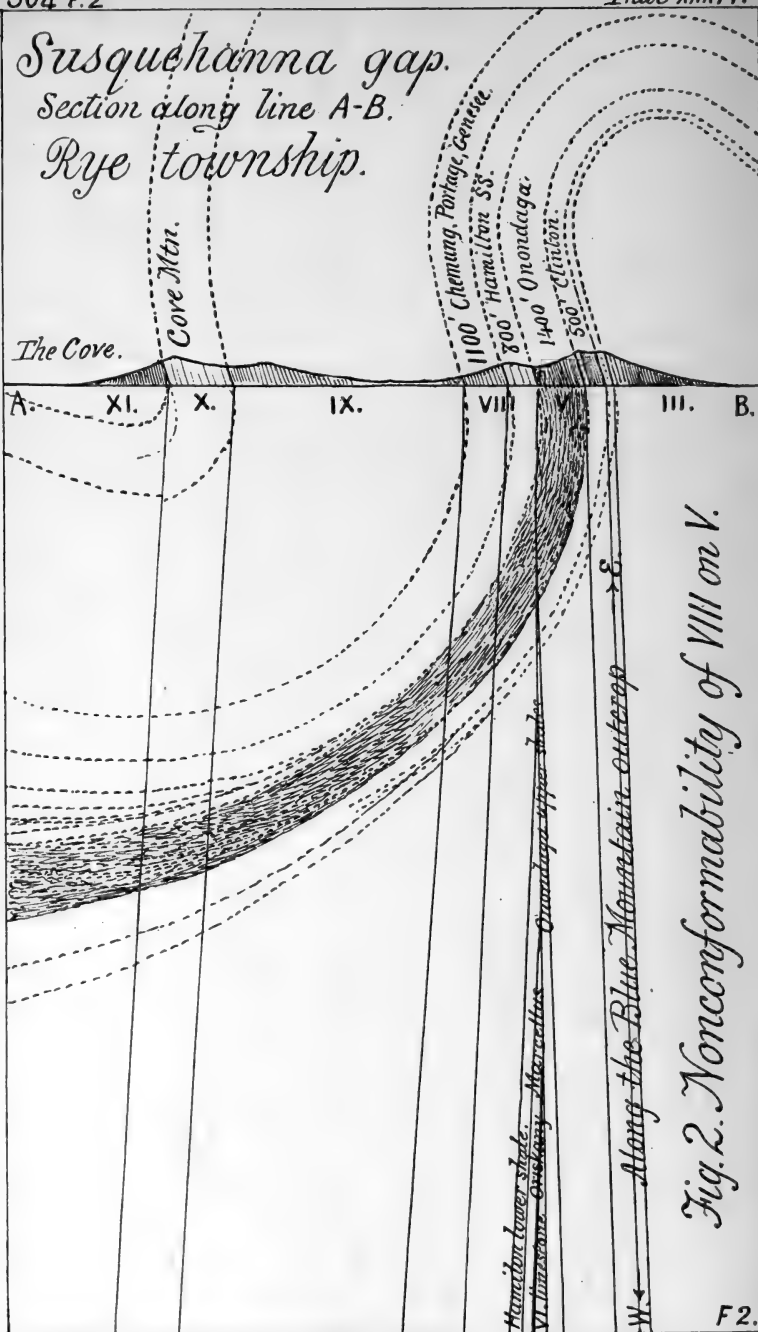
13. Rye township.

This township occupies the southeastern corner of the county. It is long and narrow, consisting for the most part of two valleys with their containing ridges. The crest of Cove mountain forms its boundary on the north and that of the Blue mountain, an extension of the Kittatinny range, on the south. The Susquehanna river washes its eastern margin, and a nearly north-south line from the great bend of Cove mountain limits it on the west. The narrow Polecat valley extends along its whole length from east to west between the Blue mountain and a range lying to the north of it called Little mountain. A broad open vale occupies the middle of the township between this range and the Cove mountain. Its length and breadth are 11 and 3 miles respectively, making its area about 33 square miles.

Only one of these three vales is wide enough to afford sufficient gathering ground to maintain a stream of any importance. Fishing creek drains the middle of the township, receiving its waters from the slopes to north and south, and delivering them into the Susquehanna below Marysville. The western end of the township is drained by a small stream which falls into Sherman's creek in Carroll township.

The geological structure of Rye township requires a few words of comment. In one respect it is unique in the county. Several groups of rocks elsewhere continuous here fail and disappear. There is a great gap in the geological history which must be filled up from other places. The record is here very imperfect. Long ages passed by and left no imprint of their passage. It is even probable that they destroyed some of the records that had previously been deposited.

The red sandstone and shale of the Onondaga group were laid down over the whole surface of Perry county, and over



nearly the whole county there followed in regular succession the Lower Helderberg limestone and flint shales, the Oriskany sandstone, the Marcellus shale and limestone, the Iron ore, the Marcellus black shale, and the Hamilton lower shale amounting in all to a thickness of 600–1000 feet. But in the east of Rye township this order is interrupted. The Lower Helderberg limestone and shale, the Oriskany sandstone, the Marcellus shale and limestone, the Marcellus iron ore, and the Marcellus black shale, and the Hamilton lower shale are all absent, and the Hamilton sandstone rests directly upon the Onondaga red shale.

This fact has great geological significance. The only measure which we possess of the lapse of geological time in Perry county is the thickness of the rocks that were deposited as that time passed by. Where the rocks are thick we infer, other things being equal, that time was long; where they are thin, the contrary. Where there are no rocks it would, therefore, seem fair to infer that no time elapsed. But we are precluded from doing this by the occurrence of rocks in other townships of the county which must be placed in this interval. Plate XXXIV, page 302, Fig. 2, is meant to show the missing formations in Rye township:—

<i>In other townships.</i>		<i>In Rye township.</i>
Catskill.		Catskill.
Chemung.		Chemung.
Portage.		Portage.
Genessee.		Genessee.
Hamilton Upper shale.		Hamilton Upper shale.
Hamilton Lower shale,	. . . . .	Wanting.
Marcellus black shale,	}	Wanting.
Marcellus iron ore,		
Marcellus limestone,		
Marcellus shale,		
Lower Helderberg shale and limestone,	. . . . .	Wanting.
Onondaga.		

The five bracketed together being thin, are represented by one layer in the section.

The question naturally follows: Why were these strata not deposited in Rye township as elsewhere? And geology has but one answer: This part of the county was above sea-level during some portion of that interval. This is the geo-
20 F^o.

logical interpretation of the absence of a stratum, if that stratum occurs in close neighborhood to the place. Wherever the sea exists there sediment is deposited, and there is no reason to doubt that the same was true in the past. Consequently the inference is logical that wherever sediment was not deposited there was dry land. We thus come to the conclusion that Rye township was above or nearly above sea-level during part of the interval that elapsed between the close of the deposition of the Onondaga shale and the commencement of the deposition of the Hamilton sandstone which lies upon it. This is the earliest glimpse of land revealed in the county.*

Here is evidence of one of those changes of margin and level to which allusion was made in the chapter on the early geological history of Perry county, one of those fluctuations to which the palæozoic ocean of North America was subject in consequence of variation in the rate of depression and deposition. By this variation Rye township was temporarily raised above the water-level, and other changes, now to be mentioned, were induced.

After what has been already said on the subject of erosion no proof will be needed of the assertion that if Rye township was above water at the time in question some part of the surface must have been washed off. The amount we have at present no means of determining. Now an examination of the ground has shown that over such part of the township as allows an opportunity for inspection the Onondaga gray shale and some part of the Onondaga variegated shale are absent. This is the case in the section at Marysville, as will be detailed below. Only a part, and that the lowest part, of the Onondaga variegated shale is there present.

The question then arises, "Were the Upper Onondaga variegated shales and the gray shale ever deposited here or have they been since removed?" The question is very difficult to answer. But judging from the facts that have been

* This was written before I had proved the absence of the Corniferous limestone over the whole county, whereby an earlier land surface was demonstrated.

obtained it appears probable that these shales once existed in full mass and that they were afterwards eroded. Careful and minute examination of the beds in the Polecat valley can alone remove all doubt and such examination will require more time than could now be afforded. On the result depends the decision whether Rye township was really elevated above the sea at the time in question or existed as a low sand bank washed and often covered by the waves. It may, however, be safely asserted that whether dry or only a salt marsh it lay so low that the erosion from its surface was not great or rapid. Its comparatively small amount warrants another inference—that Rye township was above the sea only during part of the interval in question, that is, the interval that elapsed from the deposition of the Onondaga variegated shale to that of the Hamilton sandstone. If, as maintained above, the gray shales were deposited, the township must have been below sea level at the time. It must then have risen to or above that level and remained so while they were destroyed. Furthermore their destruction must have occupied the whole lapse of time until it again subsided, that is the whole interval during which the missing rocks were deposited elsewhere. Now as the thickness of the Onondaga shale removed cannot be estimated at more than 300 or 400 feet, and as the material was doubtless as soft as it is now it is evident that erosion was not violent—an indirect proof moreover that the land was low because erosion increases at a high rate with elevation.

It follows, therefore, that the dry or nearly dry area in Rye township only existed during the latter part of the time represented by the gap above pointed out in the geological record. For to maintain that the ground was dry during the whole interval would be, as shown above, to maintain that the forces of erosion did nothing—that they were in abeyance—a geological absurdity. We may then divide the interval into two equal parts and assume that the work of erosion during the latter half of the time proceeded as fast as the work of deposition during the former. We then reach the intelligible and defensible position that Rye township was above the sea during the latter half of

the time required for the deposition of the following strata in its neighborhood :

Hamilton lower shale,
 Marcellus black shale,
 " iron ore,
 " limestone,
 " shale and ore,
 Oriskany sandstone,
 Lower Helderberg flint shale,
 " " shaly limestone,
 " " limestone,

in all about 1000 feet of rocks. We cannot yet turn this date in years, but on the basis assumed above we can make the duration of the dry land equal to that required to erode and destroy the lower four hundred feet of strata (Onondaga shale) deposited during a preceding period.

It is not necessary for our purpose to maintain any special cause for the elevation of the land at this place. The continued but probably intermittent subsidence now universally admitted during the deposition of the palæozoic rocks of Pennsylvania is sufficient. Dry land is as easily produced by a subsidence of the sea as by an elevation of the land. If the bottom of the sea in the district lying under the present Appalachian region slowly subsided, its border would be left dry. We have but to place Rye township on the southeastern side of the subsiding area to account for its relative elevation without improbability or difficulty.

It is of course impossible in the present imperfect state of our knowledge of the geology of this part of Pennsylvania to determine exactly where the boundary between sea and land at that distant epoch should be drawn. We do not know where the missing beds begin to appear, or where the drainage went during the time of elevation. But facts connected with the overlying deposits in this district suggest some further possibilities which must now be considered. Whatever doubt may exist regarding the limits of the Onondaga shales there is none in regard to those of the other group. As shown in the diagram and detailed in the pages of the

township report, each of those beds successively overlaps that below it until the last—the Hamilton lower shale—almost, and perhaps quite, reaches the southeastern part of the township, though if it there exists it is exceedingly thin. This regular overlap indicates their deposition against a subsiding shore, up which they rose successively higher and higher until at length the land sank below the sea level and the Hamilton sandstone was deposited over all.

The Lower Helderberg limestone as shown on the map thins away eastward from Oak Grove Furnace until it totally disappears before reaching Sterrett's gap. The conspicuous ridge which it forms in Carroll township gradually sinks until no trace of it can be seen. But the Lower Helderberg group can be traced by its flint beds nearly to the gap, and about the same place the last relics of the Oriskany sandstone appear. Careful examination shows that the lower beds of the limestone are first lost, and the highest, the flint-beds, persist farthest. Beyond these, eastward, the Lower Hamilton shale alone exists. All these rocks were consequently deposited during submergence, and for this reason the destruction of the upper part of the Onondaga shale was given above as the only memorial of the period of elevation.

This subsidence bringing the whole township again below the sea, and amounting to about 1000 feet, measured by the thickness of the missing beds was not improbably the means of so changing the drainage of the adjoining district as to bring on the next stage in the history of the township.

After this temporary emergence, Rye township sank again beneath the waters, and over its whole surface was laid down the massive bed of Hamilton sandstone, here 800 feet thick. This deposit indicates another important change in the history of the district. The Hamilton sandstone is a formation peculiar to this part of the State. The Hamilton group in New York and in Northern Pennsylvania consists entirely of soft material, shales and thin sandstones, the latter not abundant. But in Perry and the adjoining counties there is interbedded with these shales a heavy, hard, coarse sandstone spread out like a fan and thickening

from every point in its edge to the centre. It is thin at Selinsgrove and in Juniata county, and in the northwest of Perry county. In all these directions the sand is gradually replaced by shale.

Rye township, or rather the southeastern portion of Rye township, is the locality towards which the Hamilton sandstone gradually thickens, and consequently the nearest point, at least in Rye township, to the source of the sand. Where then was this source? We have no right to infer that the original limit of the Hamilton sandstone was at the place of its present greatest thickness. On the contrary, we must assume its former southward extension for some miles at least. But it is reasonable to infer that that extension will follow the same laws as the existing mass, and we may, therefore, believe that the source of this sediment lay towards the south; possibly the mouth of some great river, draining a continental area now imperfectly represented by the Azoic country of southern and southeastern Pennsylvania.

[The outcrop of the Hamilton sandstone crosses the Susquehanna river and runs through Dauphin, Lebanon, and Schuylkill counties. The failure of the deposits below it is also a remarkable feature in those counties, as well as in Perry county. It could not be expected that the true cause of a phenomenon, so extensive in its range, and impossible to observe south of the line of the Blue mountain, should be satisfactorily explained at the west end of its area, namely in Rye township, Perry county. But the facts described in this report make an important addition to our imperfect knowledge of the subject.—J. P. L.]

The Medina sandstone, No. IV.

This sandstone makes but small show in the township. In this part of the county it is thin, not exceeding about 100 feet, and the line is drawn so as to throw almost the whole of it into Cumberland county. Its vertical beds (slightly overthrown to the north) are exposed on the railway below Marysville, and may be followed along the south crest of the Blue mountain.

The ridge of this mountain differs in a striking manner from that of Tuscarora. The latter exhibits an even, unbroken line against the sky. The former consists of a succession of hummocks with lower places, or notches, between them.

It consists of two vertical walls, the Medina sandstone and the Iron sandstone of the Clinton group, neither of which is very massive. Between these retaining walls is confined about 500 feet of soft material—the Clinton lower green shale. Consequently the Blue mountain affords in many places a broad flat top of cultivable land, as at Sterrett's gap, buttressed on the north by the thin Iron sandstone, and on the south by the thicker but not massive Medina sandstone. Such a shale-mass forms a good gathering ground for water which finds its way out through or over the retaining sandstone walls, and has therefore cut them down in many places, in some so low as to afford gaps over which passage is comparatively easy, and of which Sterrett's gap, the main highway between Perry and Cumberland counties, is the most conspicuous example.

The Clinton group, (V.)

The southern portion of Rye township consists of an exposure of the rocks of this group in beds vertical or slightly overthrown. There is much difficulty in determining the exact thickness of every member owing to the want of clear exposures. But they may be readily traced in their respective positions, especially in the lower part of the group.

The *Clinton lower shale* occupies the middle of the Blue mountain as explained above. Consequently the top of the mountain is flat and cultivated in some places. So far as it can well be measured here this shale is between 400 and 500 feet thick. In this shale lie two beds of iron ore. No good exposure was seen, but both may be traced at Sterrett's gap.

The *Clinton iron sandstone* which supports the middle mass of shale in the Blue mountain, presents the usual appearance of a hard, purplish red sandstone in thin layers. Its thickness is from 10 to 20 feet. As usual its fragments

cover the outcrops of the adjoining beds, rendering the place of contact indistinct.

The *Clinton fossil ore* beds and their adjacent strata appear to be less developed in this township than farther north. They have never yet been opened (1883.) Whether they exist or not in workable condition is doubtful. They should occur north of the upper or northern face of the Iron sandstone. (At Millerstown the lower layer of this sandstone is the *block ore* and is about three feet thick, and the other beds occur within about two hundred feet of this.) It would not be difficult to find the place of the block ore in the Blue mountain, and its presence may be inferred from the occurrence of heavy siliceous fragments among the wreckage of the Iron sandstone. The presence of the soft fossil ore may likewise be inferred from the presence of small fragments in various places along the side of the mountain. It is possibly indicated by an outcrop of clay in which, however, several shafts sunk for twenty feet failed to discover the ore.*

An unfavorable sign is the absence of any well marked ridge of the sand-rock or ore sandstone lying between the two upper ore beds. A perceptible terrace may, however, be detected along the north slope of the mountain and about 150 feet below the summit. This is in all probability formed by the outcrop of the sand-rock and would prove a good indication of the place of the ore beds.

The Onondaga group, (V.)

The Onondaga group is very well developed in Rye township, there being nearly 1400 feet of red shale and red and green shale overlying the iron sandstone and fossil ore beds. The details of this part of the group are not well exposed in their lower portion; but a quarry near the west end of the

* Among vertical beds, such as those of the Blue mountain, a shaft is not the best means of discovering ore, because it continues in the same or nearly the same stratum from top to bottom. A more systematic and likely-to-be-successful method is a tunnel run in at right angles with the beds. This would cut directly across them and whatever lies within the space penetrated cannot escape discovery.

Susquehanna bridge gives a complete section of the upper four hundred feet, showing a large predominance of beds of red shale and sandstone and a subordinate mixture of thin olive and yellow shales between them.

The thick gray shaly beds which form so conspicuous a feature in the upper part of the Onondaga in many places in the county are here missing, or if present are as red as those below them. The thickness of the group is rather less in Rye township than farther west.

The Lower Helderberg limestone, the Oriskany sandstone and shales, the Marcellus ore and shale, and the Hamilton lower shales are all absent from the exposures in the east end of the township, and very thin at its extreme west end.

The Hamilton lower shale, (VIII.)

These beds, which reach a thickness of about 500 feet in the middle of the county, thin down in Rye township and altogether disappear at the river, unless the shaly lower beds of the Hamilton sandstone be considered to represent them. As these latter are fossiliferous (containing species common in the sandstone), and the shales are remarkably barren at every outcrop in the county, the former view is the more probable one.

The Hamilton sandstone, (VIII.)

The Hamilton sandstone is well exposed in the township. Its outcrop forms a conspicuous ridge called Little mountain which runs in a straight line from west to east. It is in fact a continuation of the same range in Carroll township, where under different names it may be traced to the eastern end of Dick's hill.

Little mountain, like almost all the other Hamilton sandstone ranges in the county, is steep, rough, and wooded. Its summit in some places is a pile of disjointed masses of the sandstone. At its eastern end, on the Northern Central railway, is a nearly complete section of this rock in which its vertical (or overthrown) beds are well shown. The total thickness here is about 800 feet greater, than anywhere else in the county where I have been able to measure it. Its

beds also are very solid, especially toward the middle, growing thinner and more shaly at base and summit.

The fossil bed so characteristic of the Hamilton sandstone, is exposed near the signal-box at the junction. This is the only section where I have been able to measure its distance from the base of the sandstone; a distance of 360 feet; placing the fossil bed a little below the middle; an horizon which it appears to occupy generally, though the figures probably vary with the varying thickness of the sandstone.

It is worthy of remark that the top of Little mountain, near this section at Marysville, yields a *Rensselaeria* (or Rensselaeriod brachiopod) which I am unable to distinguish from Hall's *R. Marylandica*. I have found it at several places along this range, but this locality is specially valuable because the Oriskany sandstone does not occur within ten or twelve miles of the locality, therefore there can be no doubt of the rock in which the shell occurs.

The Hamilton fossil ore.

An outcrop of the Hamilton fossil ore occurs in its usual position along the northern slope of Little mountain on the top of the Hamilton sandstone. It is of good thickness, measuring in the gangway at the end of a tunnel recently driven by Messrs. Seidel about 28 inches. The ore was first discovered at Lamb's gap about four miles west from Marysville and has since been followed almost to the river. There is no reason to doubt its continuity westward through the township along the north flank of Little mountain, but at present prices and with present means of carriage there would be little or no profit in digging it.

An analysis of the ore from Mr. Seidel's land taken from an old opening was made some years ago with the following result (see M³):

Metallic iron,	25.5
Sulphur, . . . . .	.014
Phosphorus, . . . . .	.267
Siliceous matter,	45.220

These figures show a low percentage of iron and much

silica. But the ore from this bed at the tunnel mentioned above, not yet analysed, may yield a different result. It contains a larger quantity of carbonate of lime than I have seen in this bed elsewhere in the county; so much, indeed, that in many cases the fossils remain; whereas, they are usually represented by casts.

Beside the ore bed above described a second exists lower down and separated from the one above it by about thirty feet of rock. It is not now exposed anywhere and cannot therefore be examined. But in all probability this second and lower bed is really the bed which is usually worked in the county. This is the case along the next exposure to the northward—the south side of Dick's hill—where three beds exist, the uppermost being the *Fenestella shale* which at that place becomes ferriferous. This view is supported by the fossils, which agree with those of the second bed at Dick's hill but not with those of the Hamilton fossil ore bed usually mined.

The Genessee, Portage, Chemung, (VIII.)

I have not been able to completely trace the lines of these groups in Rye township. The whole mass is very thin, as exposed in many places along the north slope of Little mountain. Above Newport these rocks are 3800 feet thick; but here in Fishing creek they are all included in a space of about 1100 feet, showing a remarkable thinning down southeastward. Like all the other rocks in the Blue and Little mountains these beds are vertical or slightly overthrown and stand on edge with a dip of 95°—100° N. 30° W. They are not exposed along the railway, their edges being covered with washed material from above.

These rocks present no unusual features in this township but it is worthy of notice that so far as can be determined by a superficial examination the hard, sandy Upper Chemung beds of Newport are not present, or if present are not hard, so that no bold ridge is formed along the valley by their outcrop.

The Catskill group, (No. IX.)

The whole of the open portion of Fishing Creek valley is underlaid with the red shales and sandstones of the Catskill group. The latter extend far up the southern slope of the Cove mountain, whereon they form a terrace, continuous with that which under various names stretches from Duncannon round the Horse Shoe, where it is called Pine Hill.

As in the rest of the county this group of rocks supplies a fertile soil with a rolling surface. No very good exposures have been met with, much of the ground on the slope of Cove mountain being strewn with the wreckage of the overlying Pocono sandstone.

These sandstones and shales retain in Fishing creek the full thickness assigned to them in the middle of the county—about 6000 feet. Their beds are nearly vertical, diminishing in steepness to the northward where they pass under the Pocono sandstone.

Several attempts have been made to discover ore in the rocks of this group in Rye township but hitherto without success. Specimens have been frequently picked up of specular red hematite of excellent quality but no vein of it has been opened. It is impossible to say what success may attend further efforts in this township; but experience in other townships does not encourage us to expect much; the seams not exceeding a few inches in thickness.

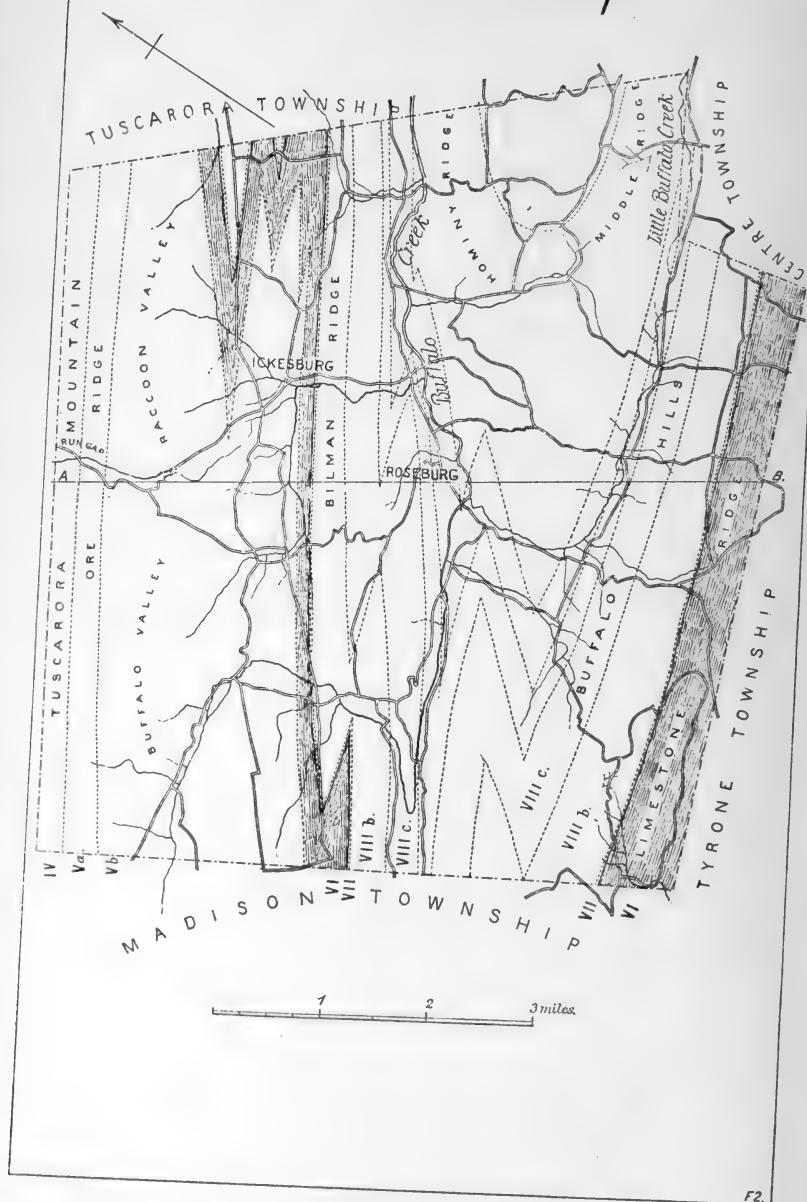
*The Trap-dykes in Rye township.**Ironstone ridge, or Great Horseshoe dyke.*

The Great Horseshoe dyke passes through Rye township almost from north to south where it is well known as the Ironstone ridge, and forms a watershed across the valley. Coming down from nearly the top of the Cove mountain its track may be followed by the characteristic belt of yellow soil and heavy rounded rusty bowlders through the woods, almost along the road, (hence called the Ridge road,) to the middle of the valley. The land on both sides of it is so encumbered with wreckage from the dyke that it is left untilled and uncleared. But it is at the crossing of the

main valley road that the most magnificent display of the Great Horseshoe dyke occurs in Perry county. Here the road for 500 feet on each side of the line is embanked with bowlders that have been removed from the land and piled up in grand disorder. The dyke itself does not probably exceed 200 feet in breadth, but its fragments strewn along both sides make it seem very much wider. North and south of this point the exhibition is less striking but the ridge may be traced without difficulty for nearly another mile, when it is lost on the slope of the Blue mountains. The nature of the trap and further details may be found in the account of Penn township.

Traces of another (the Little Horseshoe dyke) may be found, about 500 yards to the eastward, in a number of loose blocks of trap scattered along the road, but no ridge in any degree resembling the Great Ironstone ridge can be seen.

Saville township.

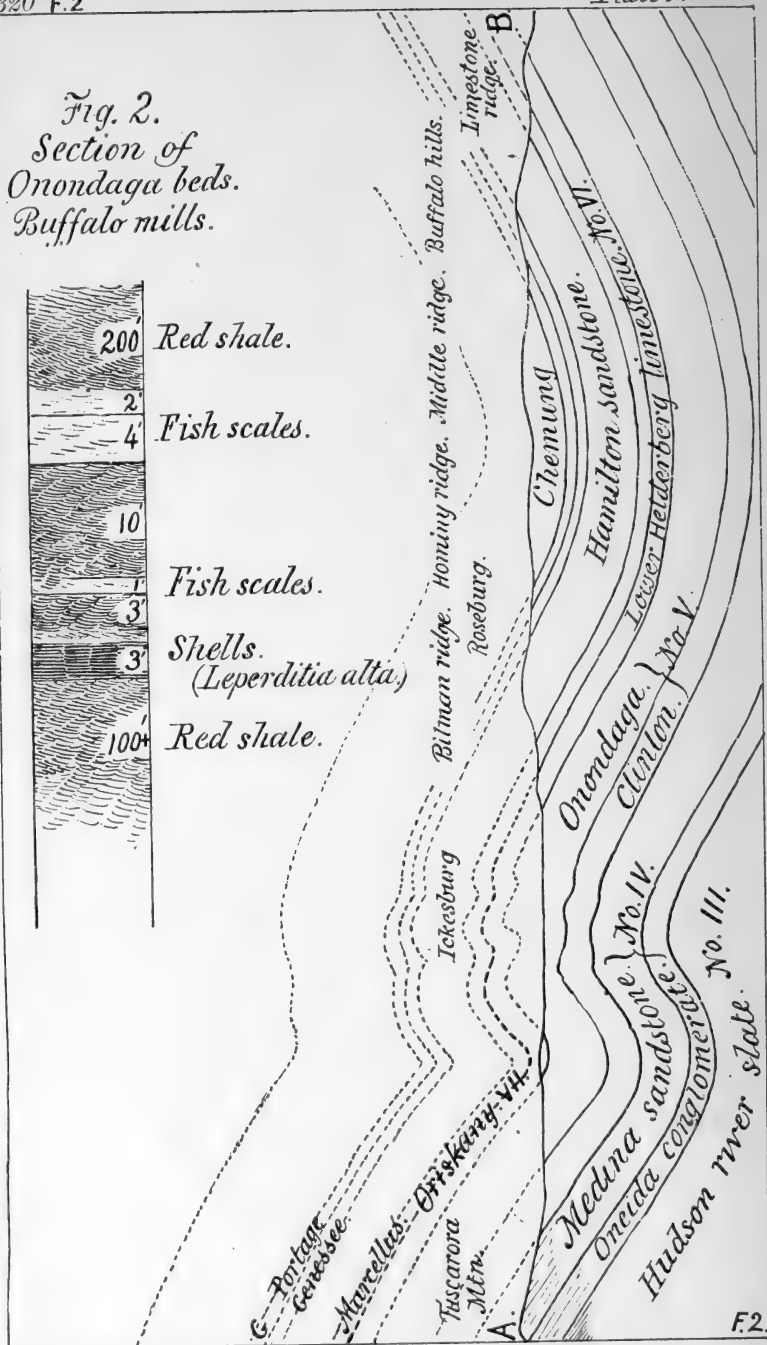
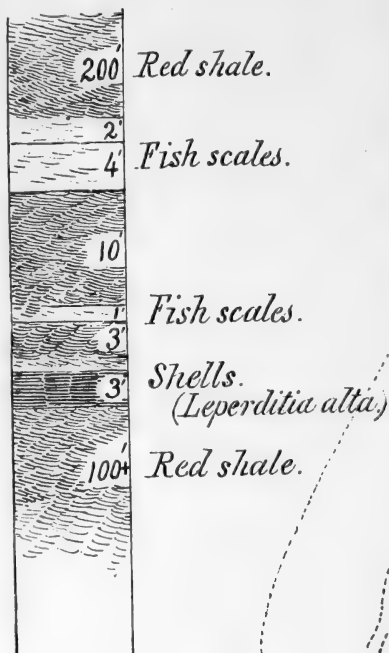


14. Saville township.

Saville is one of the largest townships in Perry county. It measures about seven miles from east to west by six from north to south, and its area is not far from forty square miles. It is interesting to the geologist for several reasons. It exhibits the western end of the Lykens valley (Buffalo) syncline, so far as concerns the Devonian rocks. These, entering it from the east, curve gently around in order and, sweeping eastward, again pass over the line into Juniata township. Their alternate hard and soft beds form a set of nearly parallel ridges, one outside of another, which, though not very boldly developed, are yet the causes of most of the superficial features. They determine the direction of the water-courses and of the roads, which run either on the ridges or in the valleys. Prominent among the former is the Buffalo creek one head of which, rising near Mannsville almost on the border of Centre township, flows westward along the valley excavated from the soft shales between the Hamilton sandstone and the Chemung upper beds of Middle ridge. The three curve parallel with each other, turn north and then west at Roseburg, after joining the main stream and pass into Tuscarora township. The successive curves of the Lower Catskill, (including the Kingsmill sandstone,) the upper Chemung and the Hamilton sandstone, with the intervening softer beds, and the Hamilton lower shale and Marcellus, make up most of the southern part of the township.

The northern portion consists of the Oriskany sandstone, the Lower Helderberg limestone and shale, and the gray variegated and red shale of the Onondaga, the Clinton group, and the Medina sandstone. The erosion of these in varying

Fig. 2.
Section of
Onondaga beds.
Buffalo mills.



degrees, according to hardness, has produced the low ground which, under the names of Buffalo valley and Raccoon valley, forms the most fertile part of the township. Narrow at the east the rising of the axis of Conococheague mountain causes its greater extension in the west where the shale is about two miles wide. The mountain wall of Tuscarora rises on the north forming a barrier between it and Juniata county and unbroken by any pass, though a ravine called Run gap, cut by a small run on the south side, makes the ascent to the crest somewhat easier than elsewhere. An irregular limestone ridge bounds the valley on the south, and the limestone is thrown up by four anticlines east of Ickesburg, which cause it to occupy a great breadth, and the three synclinal knobs form conspicuous objects in the landscape. Backing this ridge on the south and separated from it by a valley less regular than usual, in consequence, probably, of the greater hardness of the lower shale, is the Hamilton sandstone outcrop known locally as Bilman ridge, high and rugged in the east and middle of the township, but gradually flattening down as the dip diminishes, until it ceases to be prominent. Nor does it regain its former height until it returns with steeper dip at Buffalo hill after rounding the end of the syncline.

The erosion of this ridge by the Buffalo creek has formed one of the longest gorges through the Hamilton sandstone in the county, and produced some beautiful and romantic scenery. The Buffalo coming from the north strikes the sandstone and is deflected westward. It gradually cuts its way obliquely into the ridge, and after passing through it finds itself in face of another and higher one raised by the return fold formed by the north side of a short anticlinal axis passing south of Sandy hill. Instead of cutting through this second barrier the stream evades it, and turning west flows between two ridges until the anticline flattens down and the sandstone sinks beneath the upper shale after a course of about two miles. The whole length of the gorge exceeds three miles, and it is traversed from east to west by the road from Sandy hill to Roseburg, but no road

exists from north to south through the gap, the engineering difficulties being apparently beyond the reach of the township. A long detour is thus rendered necessary. All the drainage of the township is carried off by the Buffalo, except a small quantity at the southeast corner which enters the Little Buffalo, and another at the southwest which flows into Sugar run or Bixler's run.

Reports of the discovery of copper and lead ore in the slope of Tuscarora mountain have sometimes excited great interest in this township. There is no improbability of their occurrence, but hitherto mere traces have been seen, which in themselves offer little inducement to mining.

The Medina sandstone. No. IV.

The straight anticline of Tuscarora is the only appearance of this sandstone in the township, and this in itself presents no features differing from those noted in the adjoining township. Run gap, however, so called, in reality only a ravine, deserves some notice as it exhibits to the geologist the process in action of cleaving an anticlinal mountain. Some geological accident determined the outbreak of a spring in this place. The water slowly cut its way back into the slope, undermining and carrying away the rock until the mountain side was gashed so deeply that the Lower Red Medina was exposed, the only place in the whole range where it can be seen. This erosive process was accompanied by the development of other springs as the gap increased, and the quantity of water was thereby rendered larger. The gap having reached the axis of the mountain, spread both ways along it, and a longitudinal valley is consequently in process of formation which will in time extend nearly the whole length of the range. Tuscarora will then become what Conecocheague, Bower, Shade, Blacklog, and Jack's mountains have already become: double monoclinal mountains with a valley between them. *Run gap* thus affords an interesting lesson to geologists, who here see the beginning of a process which in its results becomes so important.

The Clinton group. No. V.

This group, using the word in the restricted sense established in the present report, makes but little appearance in Saville township. Its outcrop is restricted to the north-eastern part where the axes of Tuscarora and Conecocheague lift it to the surface. Its five sub-divisions may be traced along both lines of outcrop but not with equal distinctness. They are the following:

5. The Sand-vein ore bed.

4. The Ore sand-rock, $\left\{ \begin{array}{l} \text{upper, soft.} \\ \text{lower, hard.} \end{array} \right.$

3. The Upper Olive shale.

2. The Iron sandstone.

1. The Lower Olive shale.

1. The Lower Olive shale is not well exposed in the township. It might probably be found on the slope of Tuscarora but is mostly overlain with wreckage from the Medina which forms the crest of the mountain.

2. The Iron sandstone appears to be thin on the mountain, as it makes little or no show in the wreckage and forms no conspicuous terrace or foot-hill. Where Run gap descends to the foot of Tuscarora is a vast accumulation of stone brought down during past ages and accumulated on the lower slope. But it consists almost entirely of the white and red Medina without the Iron sandstone. Westward, however, this rock must rapidly thicken; a manifest terrace appears on the mountain side and in the rising slopes of Conecocheague the whole ground is strewn with its peculiar flat red slabs. Here, too, occurs the fossiliferous horizon of which fuller details may be found in the volume on the palæontology and in the appendix to the present report.

3. The Upper Olive shale is exposed in several places along the axis of Conecocheague, where it may be distinguished by the color of the soil. But it is not conspicuous and time allowed only a short examination in the township. No sign of the Millerstown (Danville) ore beds was seen in the township and they are almost certainly absent.

4. The Ore sand-rock may be traced along its line of outcrop by the color of the stone and the fossils it contains. It is difficult to distinguish it from the Medina sandstone in the Tuscarora range, but in the axis of Conecocheague on the edge of the township signs of its appearance may be seen which become more marked over the line in Madison township.

5. The Sand-rock ore bed, judging from indications, extends all along its line of outcrop—on the top of the sand-rock. But without railway carriage it is of no value and little has been done towards seeking it.

The Red, Variegated and Gray shales of the Onondaga group (V.)

These shales cover the greater part of Raccoon valley and by their disintegration form the usual fertile soil. They are well exposed in short sections in several places, especially near Buffalo mill, where the following section was obtained, chiefly remarkable for the fossil remains which it yielded (See Plate XXXVI, Fig. 2):

Solid red shale, (top,)	200'+
Greenish yellow shale,	2'
Red shale and sandstone, with fish scales?	4'
Red shale and sandstone,	10'
Red shale and sandstone, with fish scales?	1'
Sandy red shale,	3'
Greenish yellow shale,	1'
Soft red shale, (almost a soft fossil ore,) with <i>Leperditia alta</i> ,	3'
Red shale, (base,)	100'+

The above section was found about half a mile east of the mill. Close by the mill a similar section of apparently the same bed, in the same order, is also exposed. This is one of the very few places where the red shale and sandstone have yielded fossils. For an account of these the reader is referred to the volume on palæontology, and the appendix to the present report.

The Lower Helderberg limestone, No. VI.

Entering from Tuscarora township this limestone runs in a straight line to and past Ickesburg where its synclinal

beds are cut off. South of this line of outcrop four anticlinal axes develop three synclinal knobs of the limestone which show conspicuously at the quarries east of the village. The anticlines being eroded, these synclinal knobs stand out boldly, and the structure of the more southerly may be well seen. The beds are nearly horizontal but very much broken and crushed by flexure. The fracture has formed several caverns of considerable size and depth, the walls of which are covered with stalactite and the floor with a mass of stalagmite, sometimes twelve inches thick. The lower beds only are exposed and appear to have the usual thickness of about 40 feet.

The Oriskany sandstone. No. VII.

This well-marked bed crosses the township in almost a straight line, zigzagging only at the place where the Buffalo has cut its way through the several sandstone barriers into the great syncline. Probably this fold in the rocky walls has had some influence in determining the passage of the stream. The double fold here probably cracked and weakened the strata so that erosion was more easy than elsewhere, otherwise the Oriskany presents no unusual features and requires no further notice.

On the eastern line of the township the Oriskany zigzags twice, and one of the salient points thus formed extends nearly to Ickesburg. The tracing of these lines is difficult and slight errors may exist in their location on the map.

The Marcellus limestone, shale and ore, (VIII.)

The exposures of the limestone and shale of this group, which afford so valuable material in Madison township, extend into Saville. But the description given in the account of Madison will suffice. Near Sandy hill is one of the sulphur springs so common in the black shale.

The Marcellus iron ore crops out near Sandy hill and might probably be found along the whole line if sought. But its appearance is much less striking than in Madison township.

The Hamilton lower shale, (VIII.)

This shale occupies a considerable area in the township in its southern, western, and central portions. Its southern outcrop is a nearly straight line running along the south flank of Buffalo hills. Its western outcrop is a series of short low undulations caused by the flattening out of as many folds involving the Lower Helderberg limestone and Oriskany sandstone in Madison township. These undulations largely increase the area of the outcrop. Its northern exposure runs along the north slope of Raccoon ridge, but is complicated by a small fold near the west and several others near the east side of the township.

A necessary result of this geological structure is the exposure of a very large area of this shale at the surface, and the production of much poor land. The greater part of it is still covered with wood.

Conducing to the same result is another cause. In this part of the county the Lower Hamilton shale shows an unusual composition. A great part of its middle mass becomes sandy far beyond its usual proportion, and shows a close approach in this respect to the Hamilton sandstone. But instead of being, as that is, a solid, hard, white or greenish mass thickbedded and fracturing irregularly, it is a set of even-bedded, hard, dark green sandstones, varying from half an inch to six inches in thickness, and splitting with great regularity into flag-like or slate-like sheets. This structure is best seen at Mr. Shope's quarry, about a mile from Bixler's mills, where the stone has been quarried for several years. About 25 feet are here exhibited, some of it affording a tolerable but unshapely paving stone which would be valuable were it capable of being dressed square. This is, however, impracticable. Two parallel edges can be obtained, but the cross edges resist the tool, and the slab usually breaks under the hammer. This structure causes, of course, a low ridge over the country which can sometimes be, with difficulty, distinguished from the adjoining ridge of the genuine Hamilton sandstone.

The peculiar deep green color and smooth texture of the

stone render it conspicuous to the eye when used for building and walls composed of it in combination with the yellow Oriskany, the Medina and Hamilton sandstones, the Ore sandrock, the green Marcellus, and the blue Lower Helderberg limestones resemble a piece of patchwork on a large scale.

The outcrop of the stony Hamilton lower shale above described closely accompanies that of the Hamilton sandstone which is here much more shaly than at its southeastern exposure. The two are consequently less easily distinguished than usual. The broad area formed by the low undulations mentioned above in the southwest of the township, is owned for the most part by Captain Andrew Loy, and is known as Captain Loy's tract.

The Hamilton sandstone, (VIII.)

Entering the township from Juniata the Hamilton sandstone makes a bold outcrop in the Buffalo hills. But the bed gradually growing more shaly and its dip gently flattening the boldness of the ridge as slowly disappears, and in the west of the township it forms no conspicuous feature.

The set of small folds described in the report on Madison township and already alluded to in this report influences the Hamilton sandstone, which, in consequence, exhibits a series of very gentle undulations and exposes a great surface. So much has been said of this part of the township, under the head of the Lower Hamilton shales, that more is unnecessary.

The gap cut through this sandstone by the main stream of the Buffalo creek and the romantic scenery thus produced have been alluded to in the general description at the head of this chapter. The dip of the rocks at this place is about 30°-40°, and the ravine is excavated from the longest of the small synclinal folds which have been already mentioned several times. In this township the ridge is known as Bilman ridge. Further east in Tuscarora township it bears the name of Raccoon ridge.

The Hamilton Upper shale, (VIII.)

This shale enters the township from Centre near Mansville, and continues along the Little Buffalo Creek road to the water-shed. It then follows the same road along the headwater of the Great Buffalo, zigzags twice at the end of the syncline and again north of Roseburg, and leaves the township to enter Tuscarora. Numerous roadside exposures may be met with, some of which yield fossils abundantly and in good condition, especially *Spirifera granulifera*. On the whole, the exposures of this shale in Saville township are as profitable to the palæontologist as any in the county.

The Chemung group, (VIII.)

This group, as in Juniata township, forms the south slope and part of the summit of Middle ridge. Its beds are exposed along most of the roads ascending it on that side but few extensive fossiliferous exposures can be found. Curving round at the west from Middle ridge it leaves the township at the western end of Hominy ridge. The two, therefore, are really but one long continuous outcrop of the same beds skirting the end of the syncline.

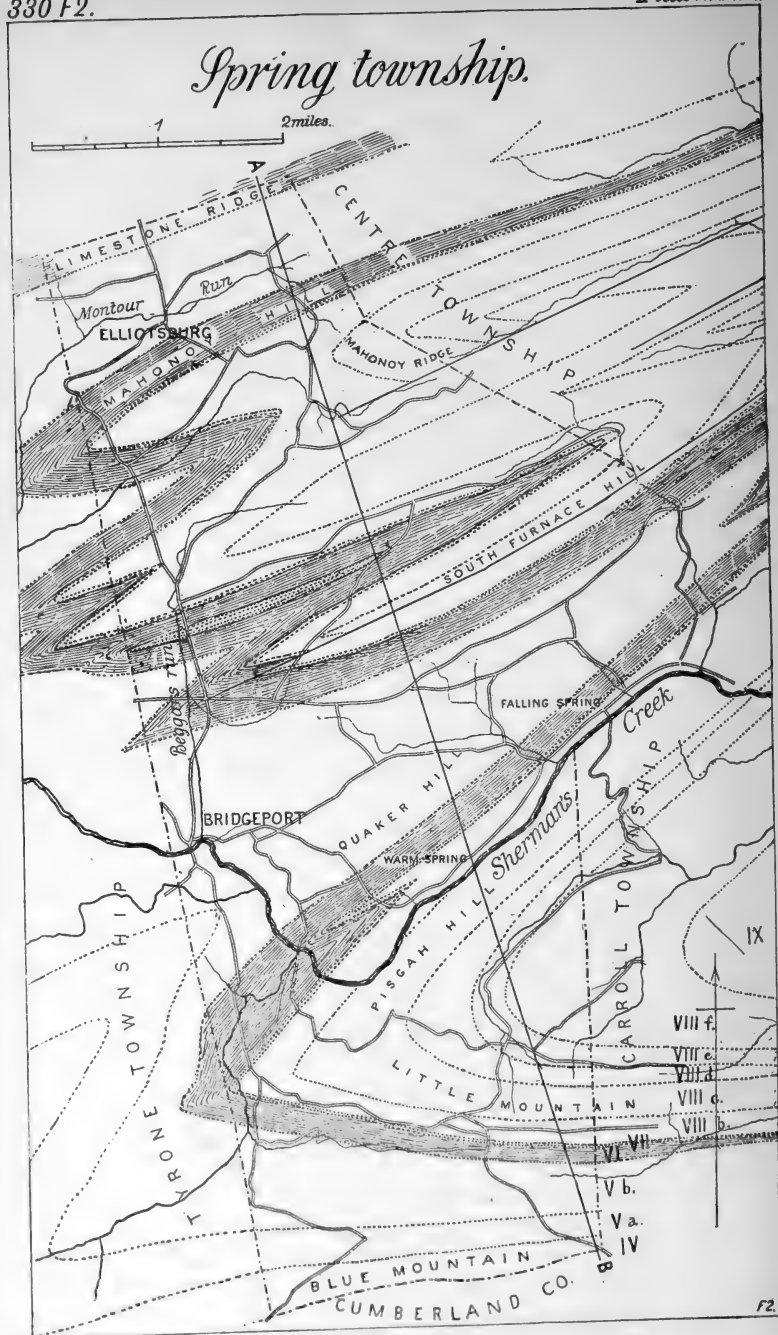
The beds of this group need no lengthened description in this township but present one interesting feature. They here display a divergence from their type in the southeast of the county in their upper portion by being more red and sandy and contain fossils which I have not found in the southern syncline. Some of the beds decidedly approach the type of beds correspondingly situated in northern Pennsylvania, in Bradford county, for instance. The Mansfield red beds which are there so distinct are indicated in Saville township. This is also the only part of the county in which I have found the common fossil of the Iron ore beds of the north, *Grammysia elliptica*. Had time allowed a larger fauna would probably have been collected. Other species, rendering the parallel yet closer, will probably be found when the material obtained is examined and studied.

The Catskill group. No. IX.

This group which forms so conspicuous a feature in the adjoining township, Juniata, makes very little show in Saville. Entering it on the east it consists of nothing but the end of a syncline which has been almost eroded. The red shale and sandstone of the Chemung-Catskill occupy, as may be seen on the map, only a small space on the east side of the township. They dip very slightly to the E. N. E., E. and E. S. E. and immediately pass under the bed next to be noticed, the Kingsmill sandstone.

The Kingsmill sandstone coming into the township from Juniata a little north of the Middle Ridge road, curves round with a wide sweep and almost immediately passes out again near the road leading to Walnut Grove school. Only at one place in the township have I seen an outcrop distinct enough to be measured. This is in a road through the woods near Mr. D. Long's, where it is about 12 feet thick.

It thus appears that the Catskill proper scarcely exists in Saville township.



15. Spring township.

Spring township is long from north to south and rather narrow from east to west, measuring about 9 miles in the former by 5 in the latter direction. It contains about 30 square miles of surface. Its only considerable water-course is Sherman's creek, which carries away the whole of its drainage.

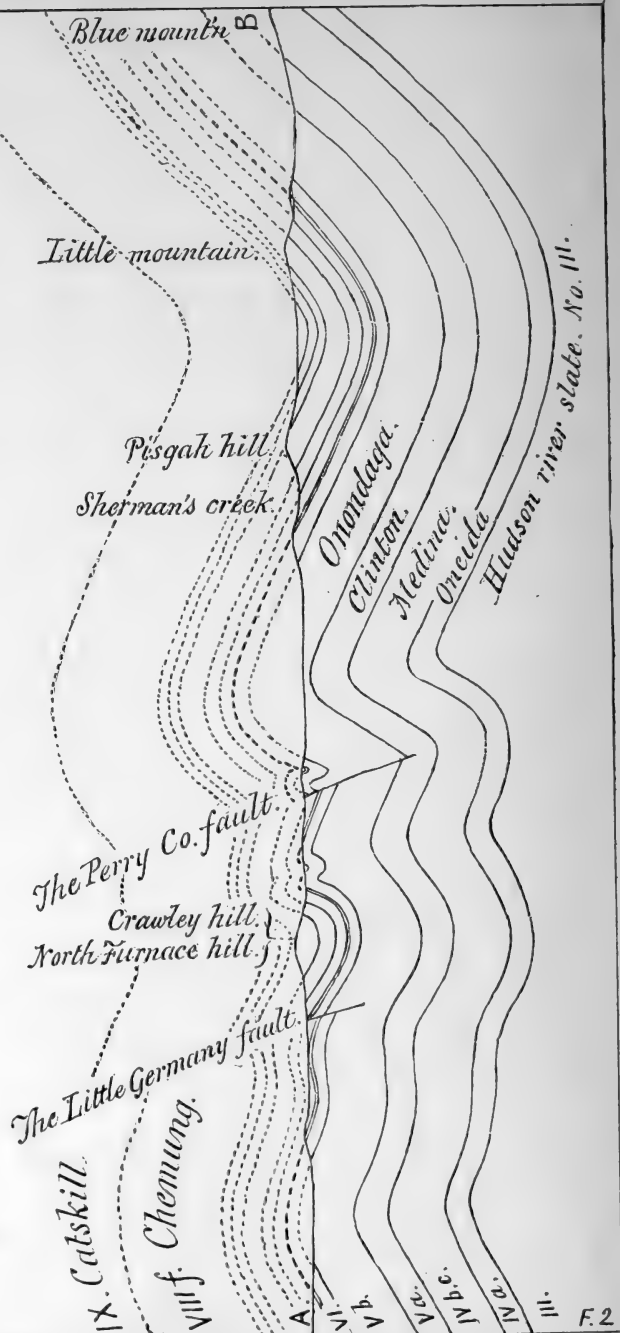
Spring is less mountainous than those townships lying to the east of it. It has, however, several short portions of forges, the greater part of which belong elsewhere.

Chief among these the Blue mountains form its southern boundary for about three miles. This range presents here the irregular summit that characterizes its whole course in the county. It is crossed by two roads, one on the western edge of the township called Waggoner's gap, and the other on the eastern edge.

Mount Pisgah in the south of the township is a conspicuous object in the scenery. It forms the meeting point of the two ranges of Pisgah hill and Little mountain, both consisting of the Hamilton sandstone. The two synclinal outcrops here run out, and as is usual at such places their union so thickens its mass that the ridge rises higher than elsewhere. The waters, cut off in this angle of the mountains, enter Sherman's creek below Gibson's rock.

Three valleys of red and variegated shale cross the township from east to west. One of them occupies the northern portion near Elliotsburg, and is a part of the vale of Bloomfield, running up the middle of the county. The second is in the middle round Bridgeport, and runs through into Carroll. The third is a narrow strip in the south between the Blue and Little mountains, and forms a portion of what is known as Thudium's tract.

Section line A-B across Spring township. → S. 6° E.



The township is abundantly supplied with limestone. The outcrop of the Lower Helderberg zigzags to and fro across its northern portion, and forms a narrow line on its northern edge, and again enters and traverses it twice in the southern part. It uniformly makes high bold ridges often capped with the Oriskany sandstone. From many of these ridges beautiful and extensive views can be obtained over the county reaching from Tuscarora on the north to Blue mountain on the south, and including westward the doublings and foldings of the latter round the various closed valleys in the southwest of the township.

The northeastern part of the township is rather a wild and rough district, the confused ranges of Mahanoy ridge, Crawley hill, and North and South Furnace hills almost meet here in a focus, leaving either very narrow valleys between them, or else actually running together. The picturesque hamlet of Little Germany lies nestled in the valley between the termination of Mahanoy ridge and Crawley hill. Both these and the Furnace hills consist of the Hamilton sandstone, four lines of which, therefore, traverse the township from its eastern boundary to its middle.

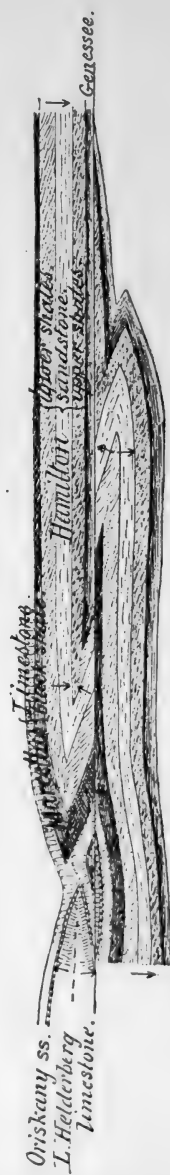
The drainage from this part of the township is brought down by Beggar's run to Bridgeport where it falls into Sherman's creek, and by the north and south branches of Montour's run which empties itself near Landisburg.

Green run, joined by a smaller one from the east, brings down the drainage of the south part of the township by Oak Grove furnace, and reaches Sherman's creek just before the latter strikes the sandstone of Pisgah hill, and is deflected to the northwest, a course which it is compelled to follow for three miles until it passes through the gap which it has made for itself at Gibson's rock.

The Medina sandstone, No. IV.

A narrow strip of the sandstone forms the southern edge of the crest of the Blue mountains in Spring township. Its length is less than three miles, and it calls for no longer notice.

Little Germany fault in Spring and Centre townships.



The Clinton Lower green shale, (V.)

These beds form the crest of the Blue mountains, buttressed on the south by the Medina and on the north by the Iron sandstone next to be mentioned.

The Clinton iron sandstone, &c., (V.)

These hard, dark-purple, resisting beds form the northern edge of the crest of the Blue mountain in the township. In this part of the county the iron sandstone attains a much greater thickness than in the northeast and rivals the Medina in mountain-making power. Its thin, flat, but almost indestructible, plates strew much of the red shale land spoiling what would otherwise be well adapted for cultivation. They are carried along by the streams and lie along the banks of every water course which passes near or over the outcrop, often exciting curiosity regarding their mineral value in places where they are not otherwise familiar. It need not be said that their mineral value is "nil."

The higher beds of the Clinton occur only on the slope of the Blue mountain, and need little mention. The ore sandrock and upper green shale are both concealed for the most part, and I have seen no exposure of the Sand-vein ore bed in the township.

The Onondaga shale, (V.)

The northern outcrop of this shale in Spring township is the summit of the eroded Bloomfield anticline, which is here cut down so far that the variegated shale is exposed over a space about a mile in width between Limestone and Mahanoy ridges. Over this tract runs the main road up the valley through Elliotsburg. The higher beds of the Onondaga should be exposed on both north and south sides of the valley, but much of their surface crop is deeply covered with the wreckage from the limestone and Oriskany sandstone.

A small tongue of the same red shale also runs up south of *Bell's hill* or *Bell's Cop*, but it requires no special notice.

The great tract of shale in this township is that around

Bridgeport and extending thence to the east and northeast. In various parts of this exposure may be found all the upper portion of the group including the gray calcareous beds and the variegated shale as well as the red shale proper. But owing to the irregularity of dip and the flatness of the ground the measurement of its thickness would require much time and care.

Another shale tract occurs in the south occupying the valley between Blue mountain and Mount Pisgah. It is part of the Polecat valley, extending from west to east and gradually narrowing towards the Susquehanna where, near Marysville, it is too narrow for profitable cultivation and is consequently still covered with wood.

The softness of the shales is the geological cause of these valleys. Exposed for ages to the wash of rain and the carrying agency of streams, their surface has been gradually worn down leaving the somewhat harder portions protruding until the whole now forms a gently undulating surface which is as suitable for farming purposes as any land in the county. The soil, too, is warm and fertile, standing well in comparison with the limestone land adjoining it, which is the strongest and most durable soil.

The Bridgeport sandstone, (V.)

This very singular bed of hard flinty sandstone is found in Spring township. One of its best outcrops is on Sherman's creek, south of Bridgeport, where it is brought up by the extension of the Welsh mountain anticlinal. Both sides are visible, dipping from the middle line with a gentle slope, and disappearing in a few yards. It is here about 8 feet thick and very hard and solid in the middle, but more soft and shaly toward the top and bottom. It is somewhat thicker in Tyrone township, but nowhere coarser than here. It is used as a rough building stone, but like the Oriskany cannot be dressed with success as it breaks very irregularly.

How far it extends eastward cannot be known. Its elevation contributes to the formation of Quaker hill under which

it passes. The overlying red shale is not yet eroded deeply enough to expose it anywhere else in the township. See report on Tyrone township.

The Lower Helderberg limestone, No. VI.

This limestone forms an exceedingly intricate line or rather many lines of the outcrop in the township. A narrow strip of it occupies the northern edge, the township line running along the ridge. Its beds dip to the N. N. W. under the Oriskany sandstone, which, together with the flint beds, caps the hill north of Elliotsburg.

The next outcrop of this limestone is on the hill south of Elliotsburg, where it spreads over a large extent of county. The details of its structure must be sought on the geological map of the township given herewith. It forms the high round ridge called Bell's hill, and is intersected by two lines of Oriskany sandstone as is uniformly the case in all broad exposures of this thin limestone in the county.

The position of the outcrop of this limestone can be readily traced on the geological map. It zigzags back and forth from E. N. E. to W. S. W., completely crossing the county several times and at last leaving it near the S. E. corner where it is becoming thin and is on the point of disappearing.

The lime shales are shown on Sherman's creek near the Falling Spring and again near Mr. F. Gibson's in an old abandoned quarry. In the former the *Stromatopora* bed is well shown and forms a complete band in the rock.

Garber's Quarry section.

Rubbly shaly limestone,	5' 0"
Coral bed, <i>Stromatopora</i> , &c.,	5' 0"
Rubbly limestone with crinoid stems and <i>Rhynchonella for-</i> <i>mosa</i> ,	12' 0"
Solid dark blue limestone with <i>Beyrichia notata</i> ,	8' 0"
Dip 20° S. 30° E.	

The top beds of this quarry lie about 300 feet horizontally, 100 feet vertically from the outcrop of the Oriskany sandstone which here shows itself in place.

The development of the coral bed in the southern exposures of the limestone shale is remarkable. In the typical section at Clark's mill it contains scattered but abundant masses of *Stromatopora* and a *Favosites* or *Fenestella*. In this quarry it exhibits a mass 5 feet thick of more or less silicified masses of the former genus with a few interspersed nodules of the latter, generally if not always, calcareous. Many of these can be cleaned by the use of muriatic acid and give a fair representation of the original form.

The Oriskany sandstone, No. VII.

The map of Spring township given herewith shows that the course of the Oriskany sandstone is exceedingly erratic. To understand the nature and cause of this complexity the map must be compared with the section across the strata. It will then be seen that the superficial lines on the map are merely the outcrop of folded and contorted beds which have been forced into their present position during the general crumpling to which the strata in this part of the State have been subjected.

Only a few of the more conspicuous or determinate can here be noticed. The ridge south of Ellitsburg is a continuation of that which appears at Half Falls mountain, forming a dam across the Juniata. It passes thence close to Pine Grove church, may be seen south of Bloomfield, and thence traced along the valley westward.

The ridge crossing the road at the residence of the Messrs. Rice near Landisburg comes almost in a straight line from the Perry furnace, and is called in this report the North Furnace ridge. At the Perry furnace it turns round the anticline and returns west-southwest almost parallel with the preceding until it ends in a high bluff above Adam's Glen school-house two miles north of Bridgeport. Here the Perry county fault, to be presently noticed, cuts across it, producing, however, a very small displacement.

Another line of this sandstone enters the township at Gibson's mill after running down the north side of Sandy hollow. Hence it forms the north bank of Sherman's creek

beyond Falling spring and Warm spring (near which occurs a small fold) to the high knob west of Oak Grove furnace, where it crosses the line and for a short distance runs into Tyrone. Returning, its course is nearly due east to the township line. As it approaches this point it becomes less conspicuous, apparently in consequence of thinning down.

Along its whole outcrop in the township the Oriskany preserves its usual character in the county of a hard, rough, ferruginous sandstone.

Two excellent springs of cool soft water issue on this horizon at Falling spring, and contribute much to the volume of water which here enters the creek.

The Marcellus shale and limestone, (VIII.)

The rocks of the Marcellus group are, on the whole, well exposed in Spring township. They nowhere in the county afford large outcrops, being thin and much covered with wreckage. But on several scattered places they make an appearance sufficient to show their continuity and consistency.

The largest exposure is near Gibson's mill where by the roadside about half a mile and again about a mile north of mill and along the creek, near Falling Spring, there is a fair display of the harder beds of the limestone which is at the last-mentioned place about 50 feet thick and contains a few fragments of trilobites apparently *Dalmanites*. At the other places above-mentioned the same fossil may be found together with *Atrypa reticularis*.

The Falling Spring, as it is called, is a small stream flowing down from the north, which, reinforced by two beautiful springs coming out of the Oriskany sandstone by the roadside very near each other, falls over the face of sandstone here nearly vertical, and then reaches Sherman's creek on the edges of the Marcellus limestone beds. The Marcellus ore makes no appearance.

Another partial but good section of the Marcellus limestone may be seen on the road leading from Perry furnace to Adam's Glen school-house where it is exposed in the cut-

ting through the Oriskany ridge, being brought up by the Perry county fault. The portion of the limestone and shale here exposed is about 40 feet thick and yields the fossils as mentioned above.

Two other smaller exposures of these beds may be seen near the residence of the Messrs. Rice. One of these is opposite the house. The ledges of limestone may be here seen in the road. The other is about a mile to the northward where the Oriskany ridge returns and crosses the road to Greenpark. Nearly 75 feet are here exposed, but the limits are concealed.

The Marcellus ore, (VIII.)

The zigzag folds of the Oriskany sandstone lead us to anticipate a long and intricate outcrop of this valuable ore bed in Spring township. This is the case. It would be tedious to enumerate here the various lines along which it may be looked for. Any one may trace them for himself upon the map by recollecting that the ore bed lies about 50 feet above the Oriskany sandstone (*i. e.*) on the opposite side to the limestone. There can be little doubt that Spring township contains an almost inexhaustible supply of hematite from this bed alone. Nor is this only theory, for the bed has been opened in a number of places sufficient to show that its quality and thickness are not inferior to what they are at other places in the county.

To mention all the openings that have been made would be almost impossible. A few will suffice.

At the angle where the Oriskany crops out from below the Devonian strata near Oakgrove, at the top of the knoll, great quantities of ore were taken out while the furnace was in blast. Much of the top of the hill is now honeycombed, and from time to time falls into the old working.

Again at the high point where the Oriskany runs out behind Adam's Glen school-house, two miles east of Landisburg, much ore has been mined. Few people now living in the neighborhood recollect the time, as the bank has been closed for nearly fifty years.

Though no attempt has been made, to my knowledge, to prove the ore along the ridges of Oriskany sandstone, running west from the Perry furnace, yet the superficial indications are abundant near the point named in the preceding paragraph for two miles or more, and the ground is very favorable for its extraction.

Again, along the south side of the high ridge running southwest from Little Germany, which is, strictly speaking, a continuation of Bell's hill, ore has been taken out and washed within the last two or three years and sent to Newport. It is needless to add that this enterprise did not pay and was soon discontinued. Continuing eastward along the same ridge, or rather system of ridges, the ore occurs again nearer to Little Germany, especially on or near the farm of Mr. Reepson and Mr. Dunn. I am not aware of its having been proved nearer to Elliotsburg, but there is no improbability in the belief that it would be found if sought.

The Marcellus black shale, (VIII.)

Spring township affords the best exposures of these beds that I have seen in Perry county. Near Little Germany, on the north road to Elliotsburg, is a quarry from which the black shale has been very largely taken for mending the roads in the neighborhood. It forms excellent road metal as is readily perceived by any one driving in that part of the township. The syncline at the west end of Mahanoy ridge exposes the Marcellus shale over a great space, revealing a small anticline coming in from the west, probably the one which runs up the valley and is cut through by the fault. Some of the lower and more solid beds are here calcareous, but have yielded no fossils except the minute sporangia which have been described from the same beds in other places.* But the blackness of these shales has deluded several of the inhabitants of the hamlet into the belief that coal *must* be found if a hole were driven in far enough, and

* See papers by Orton & Dawson in the Proceedings of the American Association for 1882 and 1883.

acting on this belief much labor has been spent in two places in the valley in fruitless effort to find it. One of these places is near the school-house and the other about a mile up the valley near the water-shed. In the latter of these a six-foot tunnel was driven 30 or 40 feet into the hill-side before the faith and patience of the diggers failed. A little knowledge of geology would have prevented the expenditure of so much useless labor. The whole thickness of the Marcellus black shale is exposed between the school-house and the saw-mill, and if any workable bed of coal existed in it its edge must have been shown somewhere on this space. No coal seam of even moderate thickness could escape notice on so large an outcrop. And there is nothing in the black shale of the hills that does not exist in the black shale of the valley.

I was informed by Mr. Smith, who has bored numerous holes to slight depths in the country round Little Germany, that he once found what he considered a bed of coal about three inches thick. Such seams are known in the Marcellus in several places in the county, but it need hardly be said that they are totally worthless.

Another good display of nearly the whole thickness of the black shale occurs close to the residence of the Messrs. Rice, and the exposure of the Marcellus limestone just described. It shows about 80 feet, which is about its full amount here, though some part is doubtless concealed under the road. One note-worthy feature at this point is the gradual transition from one bed to another. The black shales of the base, rusting to an ochreous color, slowly lose their rust, and higher still the black fades into a lighter shade and then into a pink, which merges so gradually into the gray of the Hamilton Lower shale that to draw a dividing plane is impossible. There is no break, but slowly changing conditions of deposit are plainly indicated.

The Marcellus black shale has also been thrown out of the ore works at Oak Grove and at Adam's Glen, but no further notice is required of these outcrops.

The Hamilton lower shale, (VIII.)

As with the Marcellus so with these shales, Spring township makes a very fine display. They crop out extensively round the west end of Mahanoy ridge and Crawley hill, exposed by the erosion which has removed so vast a mass of material from the western end of the township. Along the road leading from Little Germany to McAfee's fulling mill these shales are cut through for several hundred yards, and can be well examined though no complete section is exposed. Their sandy nature is very evident; in many places they are thin sandstones, but the sandy beds are thinner and finer than in Centre township. Their great barrenness in fossils is also conspicuous, long search upon this line of exposure having failed to discover anything except a few unrecognizable fragments of brachiopod shells.

The white meager soil afforded by the decomposition of these shales is very conspicuous in this district.

Further south the outcrop of the Lower Hamilton shales affords few or no exposures, being covered as usual with the wreckage of the Hamilton sandstone.

The valley caused by the Little Germany fault, along which runs the road to New Bloomfield, affords a very fine display of the lower part of the Hamilton lower shale. The high knob about a mile from the hamlet is entirely composed of these rocks with a base of black shale. They are brought up by the fault and abut against the upper part of the same shales on the other side of it. The throw of the fault is here between 400 and 500 feet.

These shales skirt the valley along the north foot of Crawley hill, ascending high up its flanks. Near the village a tunnel was lately driven by Mr. Wm. Foose for about 110 feet into them, in the hope of finding coal "in the hill." This is the only instance with which I have met in the county where such an attempt has been made in the greenish shales of the Lower Hamilton. Yet "it is an ill wind that blows nobody good." On the spoilbank at the mouth of the tunnel I found the only crinoid, I had almost said the only fossil, in tolerably good condition, which I have ob-

tained from these lower shales in the county. One bed apparently abounded in its remains, which were strewn over the ground by the action of the weather.

The Hamilton sandstone, (VIII.)

The Hamilton sandstone is the factor of the most conspicuous though not perhaps of the most useful features of Spring township. Its hard beds cropping out across the synclinal axis of southern Perry county enclose an angle in the south of the township which is thus, except by one gap, almost cut off from communication with the rest. Mount Pisgah, at the angle of the syncline, rises high and bold, and is a prominent object for miles around. The rest of the range in the township is not high, but rough and steep on the side toward Sherman's creek, owing to the great hardness and solidity of the Hamilton sandstone. Little mountain is so named only by contrast with the Blue mountains, its greater neighbor. It would hardly have received the name had the latter not been so near. The Hamilton sandstone is so thick and solid that its outcrop forms a ridge comparable in height and mass with that of the Blue mountains themselves.

Farther north the South Furnace hill enters from Centre, and would form another sandstone wall in the township near its middle, were it not cut out by the fault which crosses the syncline, gradually thinning down to nothing the outcrop of the sandstone, and consequently lowering to nothing the altitude of the ridge. Continuing eastward this ridge turns round the end of the anticline, runs westward at the North Furnace hill, which continues in a straight line until it gradually approaches and at last unites with the monoclinical west end of Crawley hill, both forming on the east side of Beggar's run a single wooded synclinal ridge.

The long outcrop of the Hamilton sandstone forming Mahanoy ridge is partly in Spring township. Coming in from Centre it ranges west nearly to Little Germany, where it terminates in a high synclinal knob. Returning eastward the line of outcrop encounters the fault running along this valley and is cut completely through, the severed end being

displaced about a mile. In consequence of this the road to New Bloomfield passes along the valley without scaling a ridge of Hamilton sandstone, as it would otherwise have been compelled to do.

Resuming its course the sandstone ridge regains its height after its severance by the fault, and continues to the east end of Crawley hill where it again terminates in a broad, low anticlinal mound, the flatness of which has tempted enthusiastic farmers to clear and plow its summit and attempt to raise crops among the stones. But Nature has asserted her supremacy, and after a short conflict the land has been again surrendered to sprouts and huckleberries, for the growth of which it is better fitted. This, however, properly belongs to Centre township.

The Hamilton fossil ore, (VIII.)

The line of possible outcrop of this bed of ore may easily be traced by following the upper surface of the Hamilton sandstone. But I do not know that it has ever been proved or opened in the township.

The Hamilton upper shale, (VIII.)

This shale may be traced along its usual line of outcrop in a few places in the township, but requires no special mention.

The Genessee, Portage, and Chemung group, (VIII.)

No mention of this group at any length is needed. Only a small patch of its rocks exists in the township. This runs in from Carroll at the point of the syncline behind Pisgah hill, and is quite insignificant.

The Perry County fault.

The southwestern termination of the Perry county fault so far, at least, as I have been able to trace it occurs in Spring township. Coming in from Centre, it, for a short distance, almost coincides with the township line crossing the road about half a mile south of the Perry furnace. Its course may here be traced over the hill west of the road, the

northern part of which consists of the Hamilton sandstone of South furnace hill, and the southern of the limestone and Oriskany sandstone brought up by the fault. It is evident, therefore, that its throw is much less than further east where the Chemung was brought against the same limestone. Estimating the thickness as before, the total displacement cannot here exceed 1300 or 1400 feet thus distributed :

Hamilton sandstone,	600 feet.
Hamilton lower shale,	400 "
Marcellus shale and limestone,	200 "
L. H. limeshale and limestone,	200 "
	<hr/>
	1400 "
	<hr/>

Continuing to the southwestward the direction of the fault is not quite parallel to the strike of the beds, being rather more nearly east and west. Consequently it cuts continually deeper and deeper into the Hamilton sandstone, thus thinning down its outcrop until at the distance of about two miles the sandstone is altogether cut out. The South Furnace hill composed of this outcrop of sandstone therefore becomes lower and lower and ultimately disappears, and the shales between it and the limestone come together. Further than this I have been unable to follow it, there being no hard rocks except the Oriskany sandstone, the line of outcrop of which shows very little, perhaps no, displacement. Moreover the Oriskany itself is largely eroded along the line of the fault.

The Little Germany fault. (Pl. XXXIX.)

A fault develops itself near the hamlet of Little Germany, in Spring township, and runs east-northeast into Centre for nearly six miles. Though far inferior in length and throw to the great Perry county fault, it yet produces much complication and several note-worthy changes in the topography and landscape. The most important of these lie in Centre township, but several must be noticed here. The most western point at which I have been able to detect the fault is on the hill west of Little Germany where it produces a fork in the Oriskany sandstone, one ridge continuing on its

previous course while the other diverges slightly to the southward. The latter thrown up by the fault continues but a short distance before it is cut off, the ridge terminating in the middle of a field. In thus bringing up the Oriskany to the surface, the dislocation has also thrown up the limestone adjoining it, and the result is that limestone has been quarried and burnt at one side of the field, while at the distance of about 100 feet northward, or geologically speaking, below it, the Marcellus black shale lies only two feet under ground with no intervening ridge of sandstone. The Marcellus is found in its proper place about 200 feet south of the Oriskany. Following the line of fault a little further to the east, we find the Lower Hamilton shales brought up on the south side against the Marcellus on the north, and yet further the former shales occupy both sides, being in full thickness. As we approach the township line, which lies on the water-shed parting the south fork of Montour run from the tributaries of the Little Juniata, a high connecting ridge of Lower Hamilton shales rises on the south side of the fault, exposing the Marcellus at its base, and the north side is occupied by the Hamilton sandstone, through which the fault here cuts very obliquely, causing a lateral displacement of about a mile and forcing a passage through the sandstone along which the road passes from the lower to the upper shale without touching the sandstone.

Beyond this the fault lies in Centre township, but to render the account complete, a few words will be added. The fault passes along the strata as they rise to the Crawley anticlinal, leaving the synclinal west end of Mahanoy separated from the anticlinal east end of Crawley hill. The anticline of the latter is so far eroded as to expose the Hamilton lower shales for more than two miles from Little Germany. These form a stretch of plowed and cultivated ground on the top of the hill, abutting on the north against the Genessee, or probably the Portage shales, and backed on the south by the south flank of Crawley hill.

The Warm Springs.

On Sherman's creek in this township and on the land of

Mr. Bower, lie what are known in the county as the Warm Springs. They are much frequented as a picnic ground and considerable money has been expended in providing accommodation for visitors. The situation is beautiful, under the high ridge of Hamilton sandstone rising south of the creek and the low ridge of Oriskany on the other bank. The springs are three in number, reckoning only those of fair size, but they scarcely deserve their name. They throw out a copious supply of water and appear more like subterranean streams emerging into day than ordinary springs. This is very likely their true nature. Their temperature is decidedly above that of other springs in the same district but can only be called warm because the water is not cold to the taste.

On October 27, 1883, I obtained the temperature of the water as follows :

East spring,	65°
Middle spring,	61°
West spring,	60°

On the same day the temperature of the water at the Falling spring, three miles off, was 55°.

I have been told that the water retains its warmth in the winter. If this be the case the explanation above offered is less likely to be correct as streams would then be colder than springs. But in October the reverse is true.

16. Toboyne township.

This is the largest and most mountainous township in Perry county. Tuscarora mountain on the north and Blue mountain on the south are connected by minor folds each of which composes a mountain in itself. The natural line or water-shed dividing the drainage of Perry and Franklin counties is consequently exceedingly crooked, zigzagging backward and forward from southeast to northwest over the western and southern part of this township. Conecocheague, Round Top, Rising mountain, Amberson ridge, Bower mountain, and the Blue range are only so many folds of the Medina sandstone.

All the mountains named above except Conecocheague and Blue are anticlinal in structure, forming arches of sandstone. Conecocheague is a monocline or half-arch dipping to the south and Blue mountain a monocline dipping to the north.

The headwaters of *Sherman's creek* flow from the slopes of the mountains of Toboyne township. The real head of this stream is in a swamp on the north slope of Amberson ridge known as the *Bear ponds*. In wet seasons these are really three large pools of water, the overflow from which forms the longest branch of several that contribute to form the main stream, here called by some *Patterson's run*. But in a dry time they are reduced to small swampy patches of ground. From this point the brook takes its way across *Rising mountain*, which is here cut down to its base, and then enters on its long passage over the red and green shale and sandstone of the lowlands of west Perry county. It is joined by several runlets from the Round Top and Conecocheague, one of which is fed by the great spring on the mountain between New Germantown and Concord.

Brown's run rising near the Bear ponds, but on the other side of a low water-shed, flows down the long and narrow

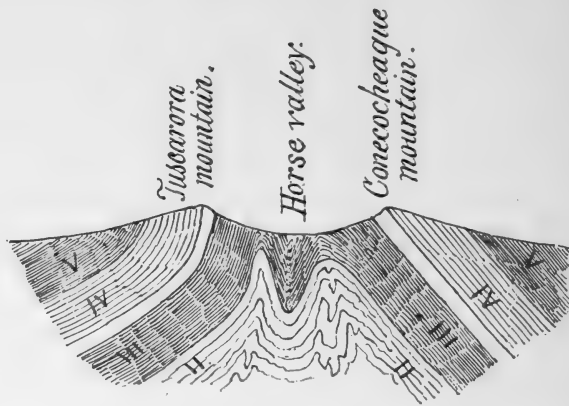
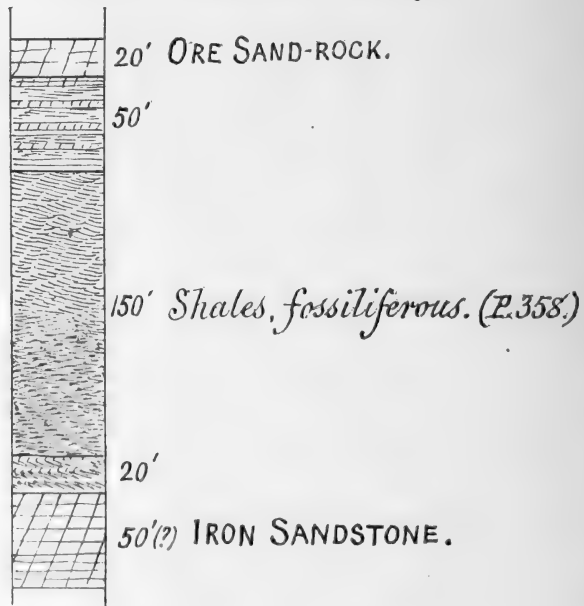


Fig. 2. The Clinton beds of the
Little Illinois valley.



Little Illinois valley and meets Sherman's creek at Mount Pleasant. *Houston's run* rises in the valley between North and South Bower, through the former of which it has cut a gap and flows along a valley (which seems to have no name) past the Monterey tannery to Beavertown, meeting Sherman's creek about two miles below Blain.

Laurel run rises in the long narrow valley between Bower and Kittatinny mountains, and flows with a very straight course till it meets the larger stream about a mile west of Landisburg.

The drainage of the Horse valley is described below.

The structure and position of the mountains of Toboyne township will be found under the head of the Medina sandstone, of which their axes consist. But beside the mountains there are lower ridges formed by the outcrop of other rocks which demand notice. Details of these will be found under the head of the Iron sandstone and the Ore sandrock. But their relations to the mountain ridges may be mentioned here.

A low range south of New Germantown rises gradually under the name of the *Buck hills* near Blain, and continues growing slowly but irregularly higher and higher until it becomes, by the outcropping of the Medina sandstone, the Rising mountain. In the same manner the *Chestnut hills* rising near Centre continue ascending until they merge in Amberson ridge.

A very unevenly crested hill called *Boyd's ridge* skirts the north side of Bower's mountain, and is composed of the outcrop of the hard Iron sandstone and Ore sandrock.

The Cambro-Silurian rocks, (Trenton limestone, Utica shale and Hudson river shale.)

Toboyne shares with Jackson township the distinction of containing the oldest rocks in Perry county. They are found in the Horse valley. Elsewhere the Medina and Oneida sandstones forming all the great mountain ranges of the county are the oldest rocks exposed at the surface, but in the Horse valley, owing to the enormous erosion and removal of material, rocks of still older date come up to day-

light. The structure of the valley will be understood by reference to Plate XL, Fig. 1.

The shaded parts of the diagram represents the existing rocks on the north and south sides of the valley. The dotted lines above it represent part of the mass that has been removed by the erosion of the strata. It will be seen that formerly the sandstone covered the Cambro-Silurian beds, and formed an anticlinal mountain of great height, and of a shape like that of the still existing ridge in Madison township. But the continued erosion cut away the top of the arch until the lower beds between or under the sandstone were exposed. These lower beds consisting of softer shale were then rapidly worn out and carried off by the two draining streams, by Horse Valley run in Tuscarora creek and by Tuscarora creek itself; further west until the present valley was scooped out and its sandstone walls being harder, were left forming two separate and parallel ranges instead of a single range as at first.

The Trenton limestone, No. II.

If the Trenton limestone occurs in the valley, its exposure must be small and indistinct. I could learn nothing of it except that occasionally pieces of limestone had been picked up near the narrows. But these may have been brought from outside the valley.

The Utica shale, No. III, a.

These, the oldest rocks certainly existing in Perry county, may be seen cropping out in the middle of the valley not far from Johnston & Brothers' saw-mill. They are black and break irregularly. Cleavage is rather strongly developed in them, and thence it is hard to determine the dip except by taking advantage of some variation in the strata. In this way, however, it is found to be nearly vertical. The shales are too soft to be of any use for roofing slate and the cleavage is not regular.

Near the top of the Utica shales a small seam of imperfect coal was found and followed some years ago by Mr. Job Hockenberry. Its quality was good, but its quantity insigni-

nificant, the thickness not exceeding an inch or two. Of course it dipped almost vertically downward into the ground, and being nearly in the bed of the creek, was soon under water. However interesting geologically, it is of no value, and it would be a mistake to imagine the Horse valley a coal mining region. See chapter V on the Perry county coals.

The Hudson River shales, No. III, b.

Overlying the Utica shales already described are the Hudson river series, a thick mass of greenish and yellowish shales cropping out on the slopes of the valley along the flanks of Tuscarora and Conecocheague. These beds contain little that calls for special notice here. Near their base, however, or perhaps in the upper layers of the Utica shales occur two springs, yielding water strongly impregnated with sulphureted hydrogen. The sulphur is deposited, after decomposition of the gas by contact with the oxygen of the air, in a delicate film on whatever object happens to lie in the way.

These shales continue southwestward through the valley to its opening at Concord narrows into Path valley.

In Burns valley the Medina sandstone appears to form the line, and consequently every lower bed must lie in Franklin county. But in two of the three small valleys at the head of Amberson valley it is almost certain that the Hudson River shales and perhaps even lower beds must crop out. The cleavage of Bower mountain over the axis takes place in Perry county, and if it had been practicable to examine the anticlinal valley there formed they would almost certainly have been found. In representing them on the county map I have followed probability rather than actual observation, but it must be remembered that the map of Madison, Jackson, and Toboyne townships is only a sketch, the time available having proved too short to allow a thorough exploration of this difficult ground without sacrificing other objects of the survey.

The Medina sandstone, No. IV.

The Medina sandstone is the most conspicuous object in
23 F°.

the geology of Toboyne township. It is the main component in the great ridges that traverse its western end, and which consist chiefly of a number of zigzags formed by the outcrop of this sandstone. The ranges are in succession from north to south as follows :

1. West Tuscarora.
2. Conecocheague.
3. Round Top.
4. Rising mountain.
5. Amberson ridge.
6. North Bower mountain.
7. South Bower mountain.
8. Blue mountain.

The township is thus divided, especially at its western end, into a series of narrow valleys separated by high rough mountain ridges seldom traversed except in quest of game and honey, or by woodmen and bark-peelers.

1. *West Tuscarora mountain* is geologically only the northern half of the arch of Conecocheague, as may be seen by looking at the diagram given above in the account of the rocks in the Horse valley. East Tuscarora mountain having subsided to the general level of the country very near the place where Conecocheague becomes double, the name is transferred to the northern part of the latter. But in reality the two are quite distinct. (The same transfer of name occurs elsewhere, as for example at the long narrows below Lewistown, where the two anticlines bearing the name of Shade mountain are geologically distinct.)

West Tuscarora forms the township and county line separating Juniata county from Perry. It is cut down in one place to water level by *Horse Valley run*, which passes out to join Tuscarora creek at *Waterford narrows* and carries off all the drainage of that part of the valley which lies in Toboyne township. A second gap in the range is Concord narrows in Franklin county through which passes the main stream of Tuscarora creek.

Conecocheague mountain forms a long, straight, even-crested ridge from its commencement in Madison to its termination at Round Top without break or gap of any kind.

Two roads only pass over it where it has its full height, one leading from New Germantown into the Horse valley and the other westward over the bend in the range to Concord. Both are rough, stony roads but are much traveled, being the only paths from the west end of Perry into Franklin and Juniata counties. Conecocheague mountain at its eastern end is a complete arch, but divides in Jackson township and from that point to its western termination is a monoclinical south-dipping range.

Immediately on leaving Perry county the ridge turns sharply, reënters the county and forms Round Top which commands the head of Sherman valley and is a conspicuous object for many miles. The northeastward course is short; for, zigzagging again it passes over the county line to the southwest, with a southeast dip, and continues for about twelve miles as a straight synclinal range (Dividing mountain) between Path valley and Amberson valley.

Returning from its long excursion into Franklin county the Medina sandstone again enters Perry and forms the high, broad, stony ridge called *Rising mountain* to the southwest of New Germantown. The arch of this anticline gradually sinks until the sandstone disappears from view below the surface and is followed by other beds forming the range known as *Buck hills*.

The southern side of the arch of *Rising mountain* after it has been divided to the southwest over the axis is continued into Franklin county where it becomes synclinal by meeting the northern side of the next fold.

It again returns northeastward with a northwestern dip and arching over another anticline forms *Amberson ridge*.

Sinking to the northeastward, as *Rising mountain* sank, the anticline rises in the opposite direction, is divided over the axis and the southwestern limb dipping to the southeast meets the north side of the great fold of *Bower mountain* and rises as a syncline into the air, forming a high knob overlooking Amberson valley.

Thus far we have three anticlines projecting themselves into Perry county and forming East Round Top, *Rising mountain*, and *Amberson ridge*. There are four corre-

sponding synclines projecting themselves into Franklin county and forming West Round Top, Dividing mountain, and the two points at the northeast end of Amberson valley which seem to have no distinct names.

In addition to these there is the great level-crested ridge called Bower mountain, the sandstone backbone of which rises in Madison township and gently slopes upward through Jackson until on entering Toboyne it forms a small zigzag, and is soon afterwards cleft by erosion and becomes two ridges which seem to have no separate names, and may, therefore, be called *North* and *South Bower*. Of these two monoclinical ranges springing from the division of the Bower anticline, (13th of Rogers,) the northwestern soon unites with the south side of Amberson's ridge, and forms the most southerly of the synclinal knobs above-mentioned. That to the southeast continues on its southwestern course into Franklin county until it ends near Clark's knob by meeting the same south side of Amberson ridge continued, the intervening part having been destroyed by erosion.

Gaps have been cut through these mountains by various streams, beside those in West Tuscarora already mentioned.

Rising mountain is cut by Sherman's creek coming from the Bear ponds on the north side of Amberson ridge. No road passes through it, and the gap is a tangle of laurel and scrub down which the little trout stream makes its way over boulders and rocks in a narrow channel.

North Bower mountain is also gapped by the head of Houston's run, and the road from N. Germantown to Shipensburg passes through the gap. Except along these lines most of the tract here described is a wilderness unpenetrated except by a few bark roads, and frequented only by sportsmen and hunters. Deer and bears yet linger here, and traces, especially of the latter, may often be seen. Occasionally both are found and killed, but for the most part the recesses of the mountains are so deep and secluded that the few remaining animals dwell comparatively unmolested. The narrow sequestered valleys are usually settled and cultivated as far as possible, but these form a very small part of the

wild country in the western end of Perry and the eastern end of Franklin counties.

The relation and position of these various ranges will be better understood by an inspection of Plate I.

The portion of the Blue or Kittatinny mountain lying in Toboyne township presents little that calls for special notice. It is like the rest of the range, monoclinical except at its eastern end, where a small fold develops itself on the north side, narrowing Schaeffer valley and corresponding to the zigzag in Bower mountain, above mentioned. On the opposite side of the range a deep gorge has been excavated which, from its form, bears the name of *Three Square hollow*.

Very extensive and beautiful views can be obtained from the tops of these mountains by those who have sufficient perseverance to penetrate their tangled brush. From spots where the timber has been cut or burnt a series of mountain ranges may be seen rising one behind another in grand outline against the sky. For instance from the summit of Rising mountain, near the middle of the region, the eye can see to the northward first the Round Top, then Conecocheague, then West Tuscarora, and beyond these Shade mountain and Black Log, and in the far distance Jack's mountain, in Mifflin county. To the east the view ranges over Perry county. Buffalo mountain, at Newport, is a conspicuous object, all the intervening country being spread out like a map. Amberson ridge cuts off the view to the south, and that to the west is in like manner intercepted by high intervening ground.

The Clinton group, (V.)

The exposure of these rocks is exceedingly complicated and difficult to trace in consequence of the effects of the axes already mentioned. It is impossible to go into any full or detailed description of the outcrops of its different beds. They are very numerous and extensive. Another difficulty arises from the incorrectness of the only topographical maps existing of the township. This has everywhere proved a barrier to careful and exact delineation, but in Toboyne township it may be said that the physical fea-

tures are roughly represented rather than mapped. At present all that can be done, either geographically or geologically, is to approach as near to that accuracy as circumstances allow. A trigonometrical survey of the State would lighten the labors of the geological surveyor.

The outcrop of the Clinton rocks follows all the zigzags of the Medina represented on the plan already given, and reaches the farthest points of the long narrow valleys into which the west of the township is divided. In Henry valley it even runs over the line into Franklin county, as in Liberty valley it passes into Juniata.

The great increase of lime in this group is very marked. At Millerstown the limestone in the passage beds over the sandrock is merely a calcareous shale; but in some places in Toboyne township, as in the Little Illinois valley, it is a good bed of limestone, sometimes quarried and burnt. The same is true of other calcareous bands. *The sand-vein ore bed* is indicated in several places as on Conecocheague and Buck hills, but in quality and quantity seems inferior to what it is further east. *The ore sandrock* is conspicuous and in some places richly fossiliferous, as on Buck hills south of New Germantown. In the Little Illinois valley is the finest exposure of this rock which I have met with in the county. The other ore beds found at Millerstown are not present here. The section given below shows the whole series of the Upper Green shales exposed on Brown's run, and the absence of the Danville ore beds is conspicuous.

Little Illinois Valley section, (Pl. XL, Fig. 2.)

Clinton hard, solid sandstone, Ore sandrock,	20'
" yellow sandstone and interbedded shale,	50'
" yellow shale,	} fossiliferous, 150'
" olive shale,	
" reddish shale,	
" iron sandstone interbedded with olive and yellow shale,	20'
" iron sandstone,	50'?

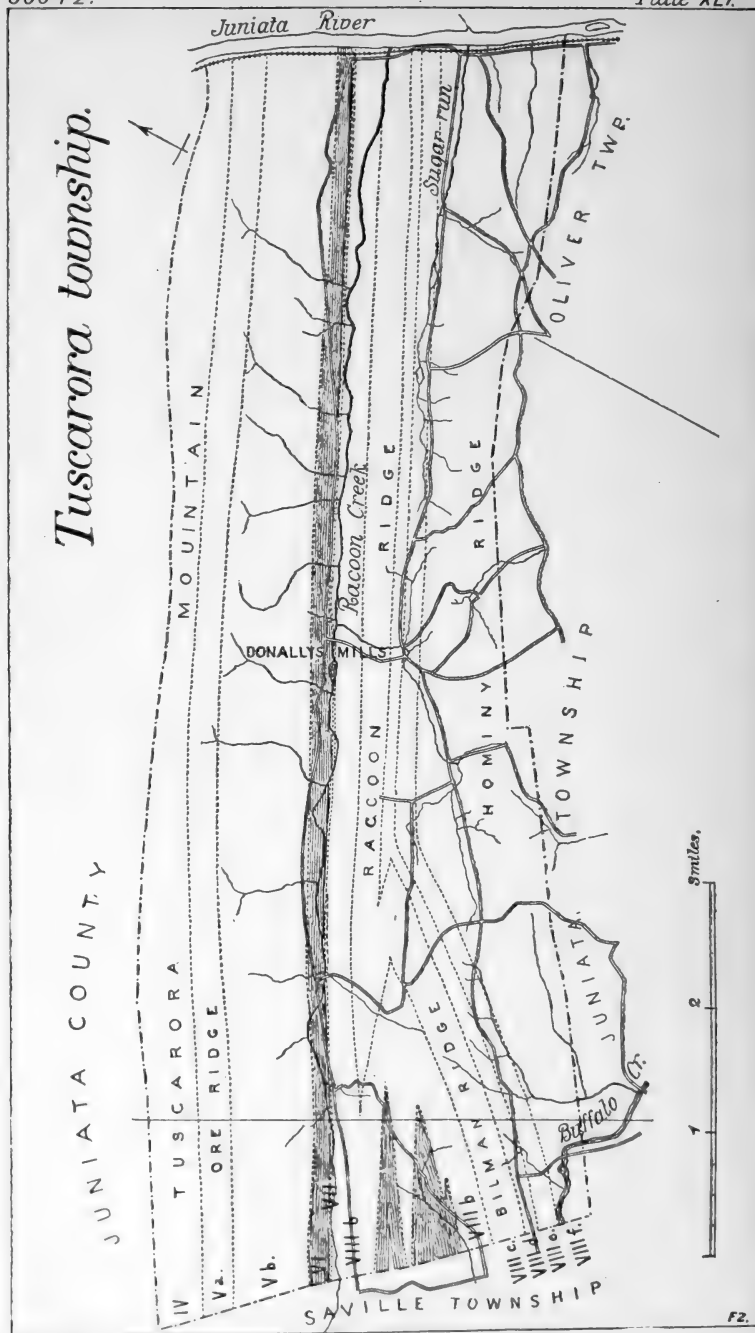
Dip 85° N. N. W. Total thickness, 290'

The Onondaga group, (V.)

All the valleys of the township are occupied by the red and variegated shales of this group, the gray calcareous upper beds having been for the most part eroded. Of the latter, however, there is an outcrop about a mile west of New Germantown where one of its beds has been quarried for lime, on the farm of Mr. Eby, the most westerly point at which they have proved of value. The other portions of the group are also more than usually calcareous, but with this exception what has already been said of the group in Jackson and Madison townships will apply to Toboyne without repetition.

No rocks newer than the Onondaga shales now exist in this part of the county, and consequently the geological history of the township ends here. All the higher and newer beds that once existed have been destroyed.

Tuscarora township.



(For section across township: see page 358.)

17. Tuscarora township.

This township borders on the Juniata county line. Its greatest length is parallel with the mountain range which has determined its outline and is about eleven miles east-northeast to west-southwest. Its breadth seldom exceeds three miles. Its area, consequently, measured on the flat, is about thirty-three square miles.

Tuscarora is one of the most mountainous townships in Perry county being traversed through its entire length by four ridges of more or less importance. The Tuscarora mountain occupies its northern edge and its crest is the county and township line from the Juniata river west to Saville township. Parallel with this runs Ore ridge, comparatively low. On the other side of Raccoon valley is Raccoon ridge. Hominy ridge lies on the southern edge of the township, parting it from Juniata and Miller. All these are cut through by the Juniata river and most of them continue under different names on its eastern bank.

All the northern waters of Tuscarora township flow down to the south-southeast, or nearly at right angles with the axis of the Tuscarora mountain. Meeting in *Raccoon valley* they turn to the east-northeast and form *Raccoon creek* which falls into the Juniata river a little below Millerstown. In like manner the waters from the southern slopes of *Raccoon ridge* and the northern slope of *Hominy ridge* meet in the intervening *Buckwheat valley* and flowing parallel with the ridges under the name of *Sugar run* reach the Juniata about a mile below the mouth of the last named creek.

The northern valley of the township is level and open and its soil is good. It is by far the best part. *Buckwheat valley* is very narrow and lying for the most part on the Hamilton Upper shale, Genessee, and Portage the land is

less productive. The valley between Tuscarora and Ore ridge is but partly cleared.

Tuscarora township, therefore, consists of three long, narrow valleys formed by four parallel ridges, three of which are heavily timbered. The fourth, *Hominy ridge*, is in part cleared, but being composed of the Chemung shales the soil is poor. Tuscarora contains more rough and uncleared land in proportion to its size than any other township in the county. The greater part of it is still covered with timber. Geological investigation is consequently very difficult and few details can be given except those relating to the Iron ore beds near Millerstown.

The Medina sandstone, No. IV.

This rock presents no feature in the township calling for special mention. Little can be seen of the section on the river, the face of it being deeply buried with wreckage in blocks large enough to produce the impression that they are a part of the bed-rock.

The Clinton group, (V.)

These rocks occupy a long, narrow line of outcrop on the south side of Tuscarora mountain.

The harder beds, the *Iron sandstone* and the *Ore sand-rock* together form a low ridge which from its contents has been called *Ore ridge*.

The lower part of the group exhibits nothing peculiar in its aspect and calls for no special remark.

The upper portion of the group contains the fossil ore beds.

For the general section of the Clinton group, see page 46.

The Upper Olive shales, often called the *Fossil ore group*, have been well exposed near Millerstown along the edge of the ridge. The following section can be seen at the works of Mr. Roundsley:

Section at Roundsley's.

Upper ore beds,	{	Sand-vein ore bed,	1'	}	11' 6"
		Sand rock,	5'		
		Hematite,	0' 6"		
		Sand rock,	5'		

Upper Olive shale and Lower ore beds,	{	Olive shale,	160'	}	3'
		Iron sandstone,	2'		
		Fossil ore,	1'		
		Olive shale,	300'	}	11' 6"
		Iron sandstone,	10'		
Lower Olive shale.		Hard block ore,	1' 6"		

The thickness of the Olive shales is here much greater than in the west of the county, and this greater thickness is accompanied with the development of the lower ore beds which do not exist there.

Only the Sand-vein ore bed is now worked in Tuscarora township; but the two lower beds are easily accessible at the river, and could be at once resorted to if the price of the ore were higher. At present about 800 tons a month are sent to market.

West from the river this ore bed has been opened in numerous places, but with one exception all are now "standing." It is not of uniform quality. In some places as at the new level driven by Mr. R. Cochran a mile west of Millerstown, the soft ore gives place to a hard ferriferous limestone, very expensive to mine and containing a high percentage of lime. (For further details see Chapter V.)

The Onondaga group, (V.)

No natural exposure of these rocks was found in this township. Its nearly vertical beds are concealed by superficial soil along Raccoon valley below the level of the openings of the ore beds. These openings sometimes begin in the red shale and sometimes in the olive shales underlying it—the passage beds. But these excavations present no features which have not been already mentioned in this report.

The Lower Helderberg group, No. VI.

The rocks of this group crop out forming a low ridge along the middle of Raccoon valley. They differ from themselves in other parts of the county by being less massive. Though no good or complete section is exposed in the township, yet the absence of the massive limestone beds

of Limestone ridge is very marked. The beds are thin, and at the few exposures at the east end of the township show only a small part of the section.

But at the west end near the border of Saville township occur the best exposures of the white flint beds that I have seen in the county. Near School-house No. 8 can be seen the section here represented :

Solid white flint,	0' 6"
Solid white flint,	0' 6"
Solid white flint,	1'
Sandy limestone with lenticular black flint masses,	4'
Sandy limestone as at Half Falls mountain,	6'

The exposure of these rocks in this part of the township is much increased by three anticlinal rolls, which are represented on the county maps by the zigzags of the color bands.

The Oriskany sandstone, No. VII.

This sandstone makes but little show in Tuscarora township, and calls for no lengthened description. A fair exposure of it occurs opposite Millerstown.

The Marcellus group, (VIII.)

No exposure of the Marcellus limestone or Iron ore has been found in Tuscarora township. It appears as if this bed of hematite were less developed in this part of the county than in the center. Nor have I observed any outcrops of the Black shale calling for special mention. All the features of these rocks may be found described in the reports on other townships.

The Hamilton group, (VIII.)

The lower shales of this group like so many others are in great part covered with forest. The sandstone, however, next to Tuscarora mountain, forms the most conspicuous object in the township—Raccoon ridge. This, as most others made of the Hamilton sandstone, is a steep, rough, wooded range forming an almost impassable barrier from end to end through which only two roads exist. One of

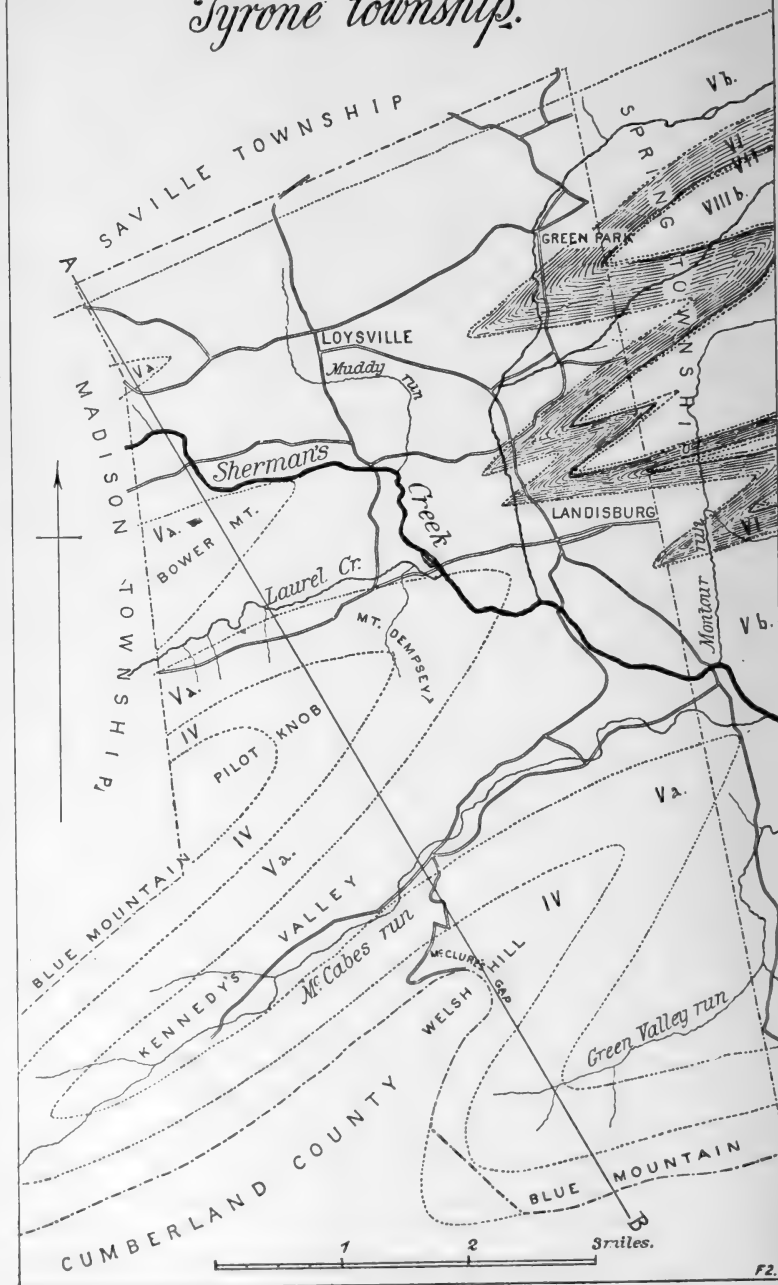
these is at Donnally's mill where a stream made up of the waters from the upper part of Buckwheat valley passes through the ridge to join Raccoon creek. The other is about two miles farther west and close to the commencement of the anticlinal mentioned above. The road through this gap is long as it cuts obliquely through the ridge and is a perfect wilderness of the great Laurel (*Rhododendron*) which grows here in greater profusion than I have seen it anywhere else in the county. Another road about half a mile farther west passes through or rather over the Hamilton sandstone where the point of the syncline is flattening down. The sandstone runs out as it approaches the limestone which appears below it.

The Chemung group, (VIII.)

Of all the soils in Perry county that on the Chemung shale is among the poorest, and of all the Chemung districts that on Hominy ridge is the most uninviting. High, steep, and rough it presents little to attract the farmer, and the wonder arises why so much of it is cleared. The streams have cut deep cross-ravines as they usually do in these rocks, and the roads winding or climbing straight up the hillsides are in some places almost impassable. This wide stretch of open or partly wooded shale land gives the geologist a clear proof of the greater thickness of the Chemung group here than at its southern outcrop at Rockville, where it does not occupy more than a third of the space.

The western part of the outcrop of the Chemung rocks combined with that of the Hamilton, forms one of the roughest parts of Perry county. Much of it has never been cleared, and it would be well to allow many acres now stripped of timber to revert to their forest condition.

Tyrone township.



18. Tyrone township.

Tyrone township is bounded on the north, east, and west by straight lines. Its southern boundary follows the curves of the crest of the Blue mountains. (See map.) After ranging in almost a straight line from the Susquehanna river westward for about 20 miles, it doubles back eastward for two miles to the knob of *Welsh hill*, thence southwestward, five miles to the head of *Kennedy's valley*, around which it bends sharply and returns to *Pilot Knob* (*Mount Dempsey*) overlooking Landisburg, thence southwestward again two miles to the Madison township corner.

Bower mountain, Mount Dempsey, and Welsh hill are made by three great arches (anticlinals) of Medina sandstone, No. IV, of different heights. (See cross-section Fig. 1, Plate XLIII.)

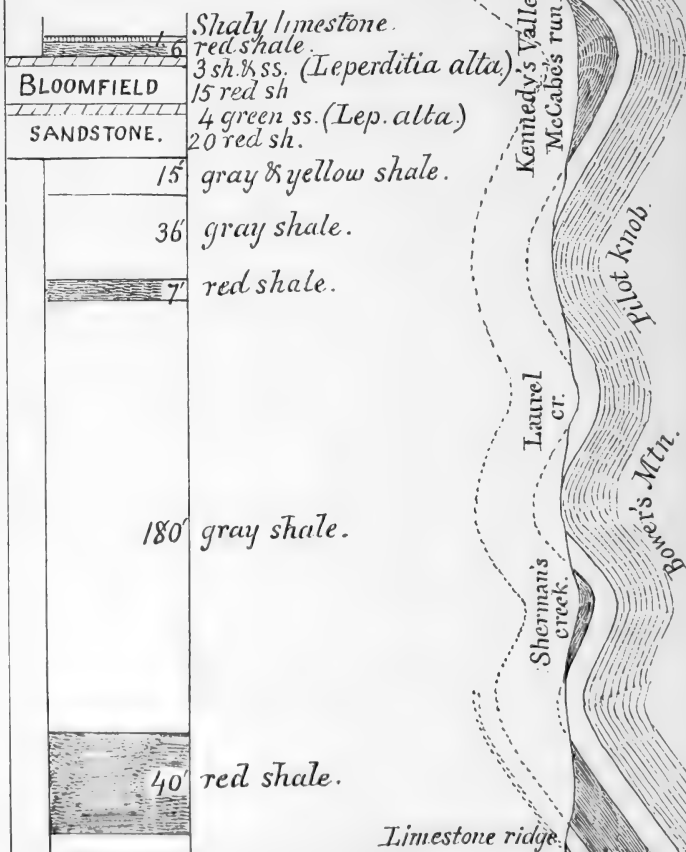
These mountains have long sloping ends towards the northeast, that is, into the township, because the anticlinal arches are sinking in that direction, and the soft Clinton and Onondaga rocks fold over and around the lower levels of these slopes.

The whole drainage of the township is accomplished by Sherman's creek and its branches flowing east-southeastward across the ends of the three mountains. In this feature of its geography, Tyrone township exemplifies the drainage-system of middle Pennsylvania.

Sherman's creek, on entering the township from the west, cuts through a high ridge of the Onondaga upper lime beds and gets into the lower shales. Further than this it cannot go, being confronted by the *Iron sandstone* of Bower mountain. So it turns and flows east until it can get round the end of the mountain, still keeping in the soft shales.

Receiving Muddy run from the north it strikes south

Fig. 2. Landisburg.
Onondaga upper
(variegated) shales.



Section across Tyrone township, along the line A.B. on the map.

over the *Onondaga shales* in the synclinal valley of Laurel creek (coming from the west between Bower and Blue mountain) to Mount Dempsey, where it cuts across the end of the soft Clinton upper shales and turns east again.

Receiving Montour run from the north, near Landisburg, it again turns southward and curves across the synclinal of Kennedy valley to the end of the Welsh hill, where it leaves Tuscarora township and enters Spring.

Receiving then McCabe's run from the west it gets round the end of the mountain in the soft Onondaga lower shales, and strikes for the last time southward to cross Green valley, but after cutting through No. VI and VII and the Marcellus soft rocks of No. VIII, it meets the hard *Hamilton sandstone*, abandons its southeast course and keeps away north eastward through Spring, Carroll, and Penn townships to the Susquehanna river at Duncannon.

[As Sherman's creek, in a small way, behaves in Tuscarora and Spring townships, so, in a larger way, the Juniata and Susquehanna rivers behave in crossing the middle belt of the State. They avoid the greater anticlinal arches by passing around their dying ends; and, as Sherman's creek gets round the ends of Bower, Dempsey, and Welsh mountains of No. IV by keeping in the softer rocks of No. V, yet is sometimes obliged to cut gaps through the smaller limestone and sandstone ridges of V, VI, VII, and VIII; so the Juniata and Susquehanna rivers while avoiding one hard formation are obliged sometimes to cut gaps through another.—J. P. L.]

That this cutting process has not always been going on at the present level of the country is evident without argument. Sherman's creek and its branches, like the Juniata and Susquehanna and all their branches, have flowed in past times at various higher levels.

I noticed round gravel lying on a hillside in Kennedy's valley 60 to 80 feet above the present bed of McCabe's run.

The Medina sandstone, No. IV.

One long sinuous outcrop of this hard and massive for-
24 F².

mation makes the southern barrier of the township as described above.

Green valley and Kennedy's valley are troughs of Clinton and Onondaga No. V in folds of this outcrop.

There is no gap in the outcrop of No. IV from end to end, but a road into Cumberland county crosses the mountain by a notch in the crest called *McClure's gap*, at the back of Welsh hill, where the Medina sandstone is cleft over the anticline.

The dip of the Medina rocks is everywhere so nearly vertical that the breadth of the outcrop nearly measures the thickness of the formation. It contains no minerals of value.

The Clinton group, (V.)

Two outcrops of the rocks of this group cross the township.

One extends along the whole line of the Blue mountains from the Spring township line, round Green valley, to Welsh hill; along both sides of Kennedy's valley; and along the north side of Mount Dempsey, passing out of the township into Shaeffer's valley.

The other saddles the end of Bower mountain.

The former of these outcrops has a length of about 18 miles, chiefly through a wooded country. High up on the Blue mountains runs the outcrop of the Iron sandstone supporting the lower green shales.

The Iron sandstone is somewhat thicker in this part of the county than in the north, and makes a visible *terrace* round the prominent points of the mountain. The terrace, however, is largely due to the *Ore sandstone*.

An excellent example of the relation of these beds may be seen in Pilot Knob. Viewed from any of the limestone ridges near Landisburg the central mass of the Medina sandstone is seen composing the highest knob, behind which in Cumberland county lies *Doubling hollow*.

In front of and surrounding it like a wall is a lower ridge formed by the Clinton outcrop, with its two sandstones. Between this lower ridge and the main mountain a trench

has been eroded along the outcrop of the soft *lower green shales*. This trench-like valley drains out through a gap in the lower rampart-like ridges of the two sandstones. The same structure prevails along the whole line, but is nowhere else so conspicuous.

The outer wall, or sandstone ridge, is, as described above, double crested ; the one crest formed by the *Iron sandstone*, the other by the *Ore sandstone*.

The upper green shales, which lie between the two sandstones, are usually less than 200 feet thick, and are protected from the weather by the covering of slabs of the almost indestructible Iron sandstone.

No trace, so far as I have observed, exists of the *ore beds* which in some other places, as at Millerstown, lie under the Ore sandstone and in the upper shale.

The *Sandvein ore bed*, on top of the Ore sandstone, is present and makes a fair display, especially in Kennedy's valley, where on the land of Mr. Egolf, numerous fragments may be seen containing characteristic Clinton fossils.

The Onondaga group, (V.)

The shales of this group crop out over the greater part of Tyrone township and yield the colored soil which it usually exhibits. They are everywhere on edge, so that their thickness is exposed in many places. It is not easy to obtain measurements on account of the difficulty of determining the exact limits of the beds. Near Landisburg, however, exposures occur sufficiently clear for the purpose. On the whole, Tyrone township affords one of the most instructive fields for studying the Onondaga group that I have found in the county.

The *Bloomsburg red shale* is well exposed to the south of the town on the road to Bridgeport, and measurements give its thickness there at about 700 feet—the same as elsewhere. This part of the group is uniform in mass over the county.

The *variegated shale*, as nearly as it was possible to determine the fact, is here of nearly the same thickness as in

other parts of the county, that is between 700 and 800 feet, measuring from the *Bloomfield sandstone* down to the solid (*Bloomsburg*) red shale.

Behind the town of Landisburg the following section can be measured :

Section at Landisburg.

(*Onondaga upper variegated shales*; see Fig. 2, Pl. XLIII.)

Shaly limestone.		
Red shale,		1'
Limestone shale with wrinkled surface,		6'
Bloomfield sandstone,	Hard green shale and sandstone with <i>Leper-</i> <i>ditia alta</i> ,	3'
	Red shale and sandstone,	15'
	Green sandstone with <i>Lep. alta</i> ,	4'
	Red shale and sandstone,	20'
		42'
Gray and yellow shale,		15'
Gray shale,		36'
Red shale,		7
Gray shale,		180'
Red shale,		40'
Total,		327'

The slabs in one of these beds of the Bloomfield sandstone are completely covered with the casts of *Leperditia alta*.

The *Gray shales* lie between the top of the section here represented and the limestone which crops out on the side of the hill. They are apparently about 200 feet thick as usual, but their summit is not well exposed.

The great extent of the outcrop of the *Bloomsburg red shale* gives to this township its fertile soil. It is the most easterly of the townships of Perry county which can boast that the greater part of its surface consists of good farming land. The shale ground extends over all the northern and middle parts of the township and high up the slopes of the mountains, running deep into the long valleys which form sheltered nooks secluded from the rest of the world, the southward sloping sides of which should produce as early crops as any places in the county.

The *red shale* saddles all the anticlines as shown on the map. A tongue of it enters the township at Waggoner's mill and extends beyond Loysville. A second comes in from the anticline of Bower mountain; a third from that of Pilot knob, and a fourth from Welsh hill. Skirting all these on north and south is a broad belt of the *variegated shale* which runs high up the valleys, occupying a broad tract in the middle of each. It may be traced in Kennedy's and Shaeffer's valleys for several miles. The *gray shales* are eroded from every part of the township except along the border of the limestone.

The *Bridgeport sandstone* (of which a description may be found in the account of Spring township) crops out in numerous places in Tyrone, especially on the sides and tops of the shale ridge in Kennedy's valley and Green valley. Here it forms rough, rugged terraces, and its flinty fragments cause much labor in clearing some of the fields. Near Mr. Egolf's saw-mill, in Tyrone township, is perhaps one of the best exposures. The sandstone has been deeply eroded by McCabe's run and its ragged edges stand out dipping at about 45° N. N. W. on the north bank. It is about 12 feet thick.

The *variegated shales* are well seen on the banks of Sherman's creek a mile and a half southwest of Loysville. About 800 feet of the upper or more calcareous beds are here visible in the middle of the troughs between Bower mountain and Chestnut ridge. The limestone bands are very thick and heavy. One of them has been quarried and burned for lime. This is the most easterly lime quarry on these beds in Perry county.

The calcareous beds, except those near the base of the section, yield two well-known fossils of the Lower Helderberg—*Leperditia alta* and *Beyrichia notata*—abundantly. The former may be found almost to the bottom of the exposed section or nearly 600 feet from its top, thus carrying the crustacean fauna of the Lower Helderberg deep down into the shale, at least as far as the calcareous beds extend.

A curious bed occurs at the same place consisting of a

limestone *breccia*, the fragments of which are subangular connected by limestone. The fragments consist apparently of the more solid beds of limestone broken down and re-cemented.

There is also a bed containing great numbers of small quartz geodes in yellow shale. It may be remarked in passing that similar beds occur in the Niagara limestone in Ohio.

The same series of beds with the same fossils is exposed on the Valley road near Cissna's run or Cedar run in Madison township. See report on that township.

The Lower Helderberg limestone, No. VI.

Three points of this limestone project from Spring into Tyrone township. The first is the point of Bell's hill near Greenpark, the second is the double pointed ridge overlooking Landisburg, and the third is a small point west of Oakgrove furnace.

At the second of these some of the fossils of the limestone shales occur chiefly in loose slabs. Most of them belong to species found at Clark's Mill. (See page —.)

Another outcrop of this limestone is on the north border of the township along Limestone ridge, the crest of which is the township line. It is long and narrow, and cultivated in most places to the top.

These outcrops yield an abundant supply of lime for the inhabitants of the township, but they present no features of special geological interest and call for no further remarks.

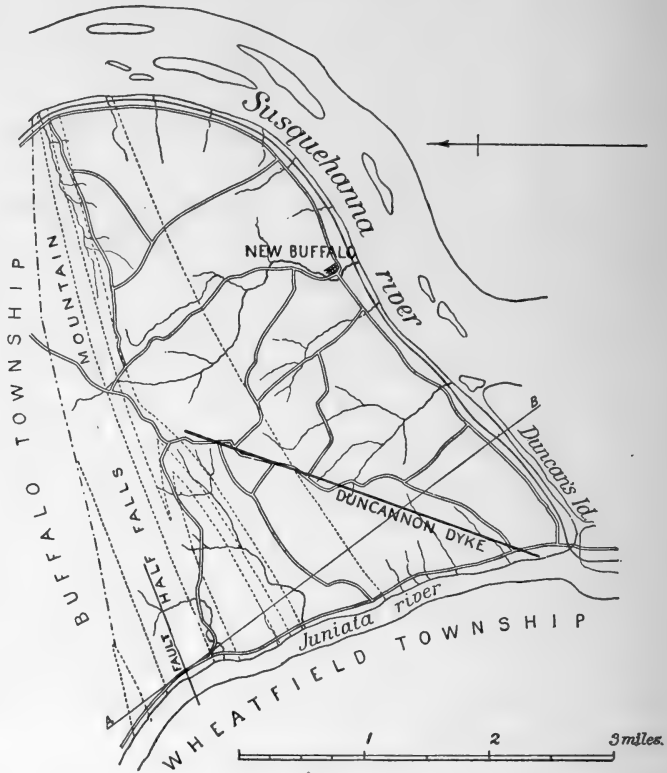
The Oriskany sandstone, No. VII.

Only the faintest traces of the Oriskany sandstone are discoverable in the township, except along the northern (Saville) line. Slight indications of the cap of Oriskany may be seen on the two hills above Landisburg, but none on the point of Bell's hill. It is seen again on the top of the knoll facing Oakgrove furnace where the long line from Half Falls mountain meets that coming in from Carroll township.

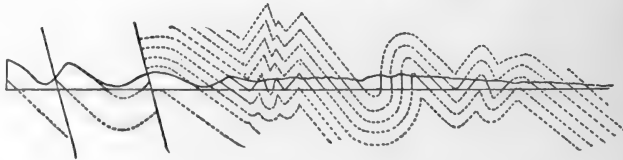
The Marcellus limestone, iron ore, and shale, (VIII.)

The only place where any trace of these can be found is at the high knoll opposite Oakgrove furnace, where the black shale and iron ore have been taken out, the latter in considerable quantity. The hill is honeycombed with old workings, and to this day a horse or a man or both will occasionally drop in.

Watts township.



Section along the line AB on map.



19. Watts township.

This township occupies the point of land between the rivers Juniata and Susquehanna, from Half Falls mountain to Duncan's and Haldeman's islands.

Its northern line is mountainous but southward it slopes gently towards the point where it is but little raised above the level of the river. The township is rather thinly settled, especially in the north where the land is rough and poor. The Pennsylvania canal runs along the river side for about seven miles and crosses into *Haldeman's island* at the southern point, the old channel between them being filled for that purpose at the west end. A third island formerly existed but since the construction of the canal the intervening channel has silted up so that it is now six feet above the usual level of the river. Consequently this (*Huling's island*) is permanently united physically to Perry county though by the original deeds and still legally it is a part of Dauphin.*

One of the most interesting features in the geology of Watts township is the abundant evidence it yields of the former flow of the rivers at a higher level. *Haldeman's island* is nothing but a former flood plain of the Susque-

*The tradition in the neighborhood is, that the earliest settler in the district, Abraham Huling, a man of unusual foresight, at least in his own opinion, bought 200 acres of land at the mouth of the Juniata commanding both rivers with a view to profit from the great city that was likely to grow up at the confluence. He did the same at the junction of the Allegheny and Monongahela. After awhile as the cities did not appear, he came to the conclusion that the latter was too far west and sold it, retaining the former. Alas for human prescience! The one is now Pittsburgh, the other is still the Junction farm and since the introduction of the railway has lost what little importance it previously had from lying on the highroad west from Harrisburg to Fort Duquesne, (Pittsburgh.)

hanna and Juniata. Rounded gravel and sand are found in every field. The same is true of *Duncan's island*, although some of it, by the deepening of the channel, is now much above the water.

Before the construction of the canal the Juniata flowed into the Susquehanna, or *vice versa*, through a channel north of the islands. Once since then, during a great flood in 1846, the Susquehanna rose over its banks, reopened this old channel and swept out the embankment of the canal.

Much of the land along the east side of the township is alluvial soil consisting of ancient river bottom, now far above the highest floods. On the west side there is no such land. The Juniata flows close under the cliffs. Many feet above this flood-plain may be found rounded and transported stones proving the ancient presence of the river at that height.

The bearing of these facts on the geological history of the county is easily seen. If the rivers were ever thirty or forty feet higher than now, they may have been 300 or 400 feet higher, for the process which is lowering their channels now has been lowering them for untold ages.

The Susquehanna thrown more and more to the eastward at Girty's notch has cut into Dauphin county and left the accumulation of alluvial soil along its western bank, till striking Peter's mountain it again flows westward. The erosion of the Catskill sandstone terrace, or north flank of Peter's mountain, by the river as it slants in to the gap, is finely exhibited.

The Lower Helderberg limestone, No. VI.

This limestone makes but a small outcrop in the township in the northwest corner. The point of limestone ridge crosses the river and enters the end of Half Falls mountain, where it has been quarried and burnt for several years. The limestone extends but a short distance inland, being soon covered by the shales and sandstone of the Hamilton.

The beds are here very much disturbed, and have yielded no fossils. Some of the layers are very sandy, but are nevertheless burnt for lime.

The Oriskany sandstone, No. (VII.)

Immediately above the limestone which crops out on the north line of the township comes a bold ridge of Oriskany sandstone about 20 feet thick, or rather less. It forms an almost complete dam across the Juniata, producing the *Half Falls*, from which the mountain takes its name. It is hard and full of the small white quartz pebbles so characteristic of it in other places. It does not form a distinct ridge as in many parts of the county and is soon overlapped by the lower shales and Hamilton sandstone.

The Marcellus shale, limestone, and ore, (VIII.)

The area in which the outcrop of these beds can be looked for in this township is very small, and I know no place where any of them can be found outside of the river bed.

The Marcellus limestone is mentioned in the report of the First survey (Vol. I, p. 138) as cropping out at Half Falls mountain, but I have been unable to find it. It may be visible in the river at very low water, but this is improbable.

The Marcellus black shale and Hamilton lower shales, (VIII.)

These shales make no noticeable outcrop in this township. The only place where they can be looked for is at and near the Half Falls mountain, and here they are completely covered and concealed by the wreckage of the Hamilton sandstone. At low water they may be seen in some places in the river bed, and are imperfectly shown in some holes dug in search of the ore bed.

The Hamilton sandstone, (VIII.)

The northern portion of Watts township consists of a mountainous district formed by the outcrop of the Hamilton sandstone in a series of converging ridges, the geological structure of which is somewhat complicated. The main axis of the ridge, whose southeastern slope continues under the whole of Watts township, passes along the dividing line from the limestone quarries at Half Falls mountain to Girty's Notch. But the southern side of this anticline is not

simple. An inspection of the county geological map will show that along this line are several distinct outcrops converging to a junction near the Susquehanna river. The ranges of Buffalo hills, Limestone ridge, Mahanoy ridge, and Dick's hill all tend directly to this point, and their near approach and ultimate meeting render the structure of the northern part of Watts township somewhat intricate.

In the first place almost immediately south of the limestone comes the continuation of Mahanoy ridge. It forms the middle and highest point of the triple ridge of Half Falls mountain, about 500 feet above the river. This prominent feature in the geography of the township continues E. N. E., gradually sinking to a lower level as it nears the Susquehanna at Girty's Notch, where its south-southeast dipping beds are well exposed. But immediately south of this ridge is a second parallel and of almost equal height, the presence of which can only be explained by the existence of a fault running along the narrow valley between the two ridges. This is probably a continuation on a rather different line of the Perry county fault running through Spring, Centre, and Miller townships, and of which an account may be found in the general report on the county. At this point the effect of the fault is to bring the Hamilton sandstone up a second time so that the base of its southern lies against the summit of its northern outcrop. There is, therefore, presented along the river side a double thickness of the Hamilton sandstone as may readily be proved by horizontal measurement. The distance from the Oriskany sandstone through the two ridges of Hamilton sandstone to the iron ore bed is about 3500 feet, which, at a dip of 40°-50°, is equivalent to a thickness of about 2400 feet. Subtracting 600 feet for the thickness of the Oriskany, Marcellus, and Hamilton lower shale, we have 1800 feet remaining. The Hamilton sandstone nowhere in the county exceeds 800 feet, and seldom reaches that figure, so that there is evidently a repetition of its whole mass and part of the upper or lower shale or both. These are, however, concealed, and therefore inaccessible. The amount of "throw" may be set down at about 800 feet.

So far as time has allowed me to determine it, this subsidiary fault extends about three miles to the east-north-east where it finally dies out.

But the fault above mentioned does not include all the complications of the Hamilton sandstone in Watts township. Immediately south of the outcrop thrown up by it occurs another, bringing up the topmost beds of the same sandstone. It is difficult to determine from the exposure whether a complete arch exists at this place or not. But the evidence I have been able to obtain leads me to the conclusion that we have here the eastern termination of the Perry county fault. The axis of the arch above mentioned is exactly in the line of Dick's hill, and the indications of rapid decline in the throw of the fault at the east end of that range prepare us to expect its disappearance at no great distance. Accordingly we here find the missing northern slope of the Dick's hill anticline reappearing from its long submergence. It once probably passed near Bridgeport and thence possibly along the present site of Kennedy's valley into Cumberland county where the anticline may still be traced. But erosion long ago destroyed it and no vestige of it now remains. This is an indication, if any such were necessary, of the great antiquity of the fault.

The Hamilton sandstone sinks rapidly at the east end of Dick's hill, so that the range suddenly disappears. From this point the exact line of the fault cannot well be traced across the low flat ground by the river side, but the reappearance of the sandstone in Watts township restores it. This outcrop runs about 33° north of east and may be traced about three miles into the township where it ends by uniting with the other ranges above described.

The northern line of this township is therefore a focus where meet all the four ridges named above which are prominent features in the geography of Perry county. From near the middle of this line they radiate—Buffalo hills to Centre, Limestone ridge to New Germantown, Mahanoy to Ellitsburg and Dick's hill, under various aliases, to Oak Grove. Geologically three of them may be traced back again—Buffalo hills, by Racoon and Wild Cat ridges, to the

Susquehanna ; Limestone ridge to Ickesburg and Millers-town and around Pfoutz's valley, and Dick's hill, by Little mountain, to the Susquehanna at Marysville. The return of Mahanoy ridge is prevented by the Perry county fault, which cuts it off near the Perry Furnace.

From the point of convergence these ranges continue as a single simple anticline to the Susquehanna river ; gradually subsiding, it there sinks beneath the water forming a reef of rocks and a rapid. Some additional details will be found in the report on Buffalo township.

A quarry was opened some years ago on the south side of the mountain about a mile from the Susquehanna, or Big river as it is commonly called in the district, but it has not been worked recently.

The Hamilton fossil ore.

An outcrop of this ore exists along the southern side of the Hamilton sandstone, but so far as I am aware no attempt has been made to open or work it except at the two ends of the range in the township. On the Susquehanna at Girty's Notch several drifts were run in some years ago and a considerable quantity of ore taken out. The property is now in the possession of the Messrs. McCormick and the ore is not worked. Its quality, so far as can be judged from appearances, is the same as in most other exposures along this line of outcrop. I was informed that the mine had been abandoned on account of the poverty of the ore but am not aware that the ore has been analysed. It is said to be very sandy.

Another exposure from which a few tons have been taken is at the other end of the mountain on the Juniata river. Here a quantity of the ore is lying with the usual appearance and of the usual quality but this opening also has been abandoned. It lies on the south slope of the ridge brought up by the fault. A few hundred yards farther south on the upper surface of the sandstone of the arch above mentioned a small hole has been dug exposing the Hamilton fossil ore, but only imperfectly.

At the present prices of iron (1883) this bed is not worth

working anywhere in Perry county. Most of the ore taken from it was mined during the years following the war when the price of iron was high.

The Hamilton Upper shale, (VIII.)

These shales may be found exposed in their usual position—over the Hamilton sandstone—wherever the ore has been opened. At Girty's Notch the *Paracyclas* shales have been largely excavated in mining the ore and abundance of the characteristic fossils may be obtained in the spoil-bank. This is the richest locality with which I have met in the county for these fossils.

The same fossils may be found at the other two outcrops of the fossil ore but less abundantly, less shale having been taken out.

Near the last of the three outcrops alluded to when writing of the fossil ore the *Tropedoleptus* bed may be found about 100 yards to the southward showing its typical color and fossils.

The Genessee-Portage-Chemung shale, VIII.

This group as shown on the map occupies a broad belt of the township extending from the Juniata to the Susquehanna. The breadth of this belt of ground, however, indicates nothing in regard to the thickness of the rocks. It is impossible to measure them here, in consequence of the numerous folds and flexures they exhibit. The cliffs along the road by the Juniata river show nothing but a succession of rocks dipping at varying angles from vertical to horizontal, and a series of anticlinal arches sometimes only a few feet, sometimes many yards across. It is consequently quite impossible to establish any subdivision in the great mass of olive shales and sandstones without much more expenditure of time than the exigency of the survey allowed.

It is, however, quite certain that the rocks of this group thin down to the southeast. Careful measurement with approximate allowance for repetition by folding would not, I think, give them here more than one half the thickness they have at Newport, only six miles away.

The outcrop of these rocks across the township gives a meager soil, with rolling surface, much cut down by streams some of which flow in valleys, the sides of which are too steep for cultivation, and are therefore covered with timber.

The Chemung-Catskill and Catskill, No. IX.

These red shales and sandstones occupy the whole southern and southeastern part of Watts township. Its surface is, like that of the Chemung rocks, rolling and cultivated. Its soil is good and well watered. Its slope is gradually to the south, giving it a warm exposure.

As with the Chemung group, so with the Catskill, the beds are much folded and contorted, sometimes standing almost vertical and at other times lying almost horizontal. Consequently the area underlaid by these rocks is much larger than their mere thickness. Unlike the Chemung, however, the Catskill group does not thin out to the southeast, but maintains its full mass, which in Watts township is probably at least 6000 feet. But its outcrop reaches from a point nearly two miles north of Haldeman's Island to the base of Peter's mountain, a distance of nearly four miles. The contortion is confined to the lower and softer beds, the harder red sandstones which form the foot-hills of Peter's mountain and pass under the Pocono sandstone dip regularly and continuously to the S. S. E.

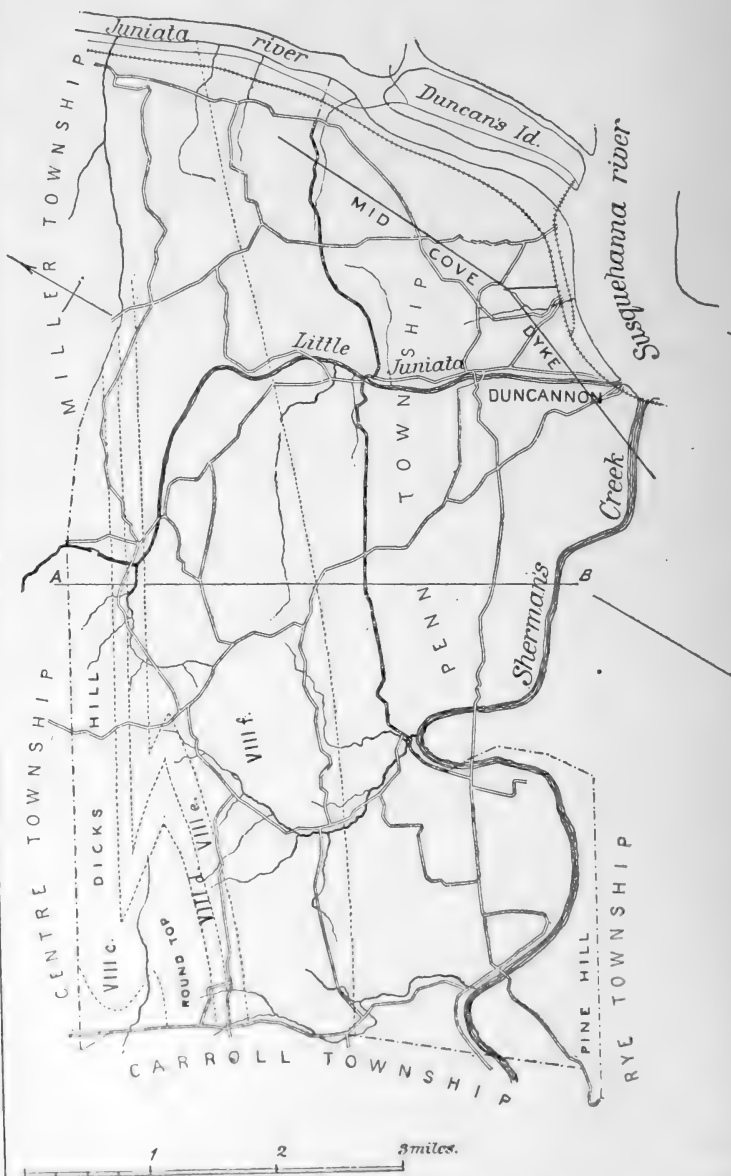
The Kingsmill sandstone shows evident traces of its presence in the township by forming one or more stony ridges of white sandstone. But in the midst of so much contortion and displacement it has been impossible to trace it, as it was traced in Penn and Carroll townships. Moreover it is not apparently so fossiliferous as there, and consequently is more difficult to follow. Enough evidence, however, has been obtained to justify the extension of the horizon through the township, though not enough to enable me to represent it with close accuracy on a map.

The East Duncannon trap-dyke.

One of the trap-dykes of which an account may be found in the report on Penn and Rye townships and also in the

general report on the county, can be followed across the Juniata into Watts township. It is in all probability a continuation of what is there named the East Duncannon dyke, which passes through the cove and across Peter's mountain near the gap. It may be seen exposed by the riverside about half a mile below Duncannon. Its course if continued along the same line would bring it nearly to the place in Watts township where the trap-rock again appears, about half a mile north of Dr. Reutter's house at the junction. This dyke must therefore cut somewhere near Duncannon the branch of the West Duncannon dyke which runs southeast from its point of division. It is precisely like the trap of Penn township—a hard, tough, dark green, almost black dolerite, containing a small proportion of magnetic oxide of iron which by rusting renders the outside yellow. From the point where it first shows itself in the river bank it may be tracked by loose blocks scattered on the roads and fields nearly to the foot of Half Falls mountain and probably had time allowed might have been followed farther. The last trace of it seen was near the house of Mr. M. Peters.

Wheatfield township.



20. Wheatfield township.

Wheatfield township lies on the south side of the Perry county fault. The crest of Dick's hill which is thrown up thereby forms its northern line. It is a long, narrow township lying for the most part on the Chemung shale and consequently consisting in so far of rather poor land. Its northern and southern portions, the former of which consists of the Hamilton shale and the latter of the Catskill red sandstone, are of better quality. Its surface as is usual with the Chemung shale is hummocky, being cut in all directions by streams. The drainage is consequently very irregular.

No steep or high ranges cross Wheatfield township except the Hamilton sandstone ridge of Dick's hill which lies close to its northern border. Its waters are carried off in four directions, east to the Juniata, west to the Sandy hollow branch of Richland run, south into Sherman's creek directly, and centrally into the Little Juniata.

The northwestern corner of the township is occupied by the great zigzag of the Hamilton group which makes a fold on approaching the limestone of Iron ridge. This fold forms the high knob locally known as Round Top and also the ridge connecting this with the main range, which bears the name Dick's Hill bridge. One of the five charcoal furnaces of Perry county was situated in this township at Montebello on the Little Juniata. Long ago abandoned, the place is now marked only by the chimneys of the old cottages, by the ruins of the old furnace and its surrounding structures, by the mass of slag not yet overgrown with vegetation, resembling an ancient lava-field, and by a single inhabited house. Almost all else has disappeared and the place by its forsaken gardens and white pine thickets re-

Section across Wheatfield township.

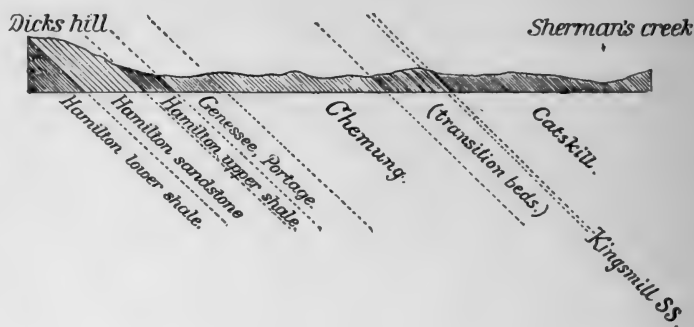
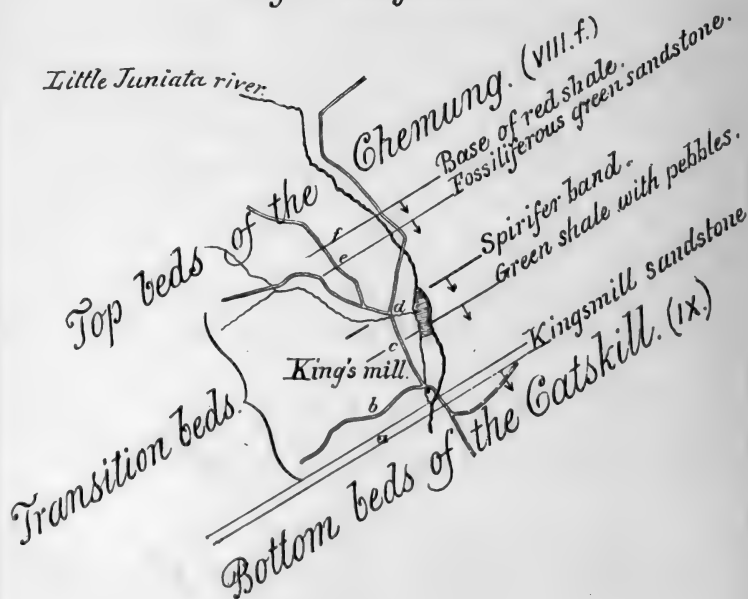


Fig. 2. King's mill.



minds the passing geologist of Goldsmith's lines in the "Traveler"—

"Near yonder copse where once the garden smiled,
And still where many a garden flower grows wild," &c.

Nature has almost regained her supremacy, and is fast restoring to the spot that beauty which the smoking furnace destroyed, and is reclothing with wood the hillsides which were stripped to supply charcoal.

A projecting point in the southwest includes a part of Sherman's creek. Delville mill, with the few houses surrounding it, is the only hamlet in the township since the decay of Montebello. At this part of its course Sherman's creek is deflected to the northward by striking the hard beds near the top of the Catskill group. After flowing north for a mile it meets the almost equally hard beds near the base of the group, and is again deflected southward. Exactly similar changes are produced in the Buffalo, in Juniata township, by striking on the same beds of rock.

The Hamilton lower shale, (VIII.)

These shales make a larger show in this township than anywhere else in the east of the county, passing along the north foot of Dick's hill in Centre township, where they are brought up by the fault, and have been cut away by the Little Juniata. They curve around the western end of the hill and crop out along the Duncannon road. They reënter the anticlinal fold forming the Bridge, and here occupy a large extent of ground. Crossing the road they leave the township and pass down into Sandy Hollow in Carroll township.

The fields at the west end of the hill show the peculiar whitish cast that characterizes these shales, and the land is of the same quality as they usually afford—rather poor.

The Hamilton sandstone, (VIII.)

This sandstone, forming the crest of Dick's hill, is thrown up by the fault which ranges along the northern foot of the hill. The dip of its bed varies from 90° to 30°, often in a

comparatively short distance. Its outcrop forms the usual rough stony ridge overgrown with timber which the Hamilton sandstone exhibits in its southeastern exposure.

Toward the west the range suddenly disappears, the sandstone descending to and below ground level by the rapid diminution of the throw of the fault, an account of which will be found in the chapter devoted to that subject.

Beyond the doubling of the sandstone by a fold at the western end of Dick's hill, there is nothing more that requires special notice. The bold peak called Round Top is an anticlinal point connected with the main range by a ridge called Dick's Hill bridge. From the Round Top the ridge enters Carroll township and a partial gap is cut through it by a small stream where the Dellville road passes.

The Hamilton fossil ore, (VIII.)

This bed crops out in its usual position along the south flank of Dick's hill where it is of good thickness, and has been mined on the land of Messrs. Dochterman, Lickel, Rathvon and Heishley. It contains the usual fossils that characterize it but requires no further mention. See chapter on the Iron Ores.

The Hamilton Upper shale, (VIII.)

As may be seen by inspection of the geological map this shale runs along the south flank of Dick's hill, keeping at the eastern end close under the ridge owing to the steep dip of the beds. It is seldom exposed, and so far as I have been able to examine it, it is less fossiliferous than near New Bloomfield. It zigzags with the Hamilton sandstone at what is called Dick's Hill bridge, and is then thrown much further southward at the western than at the eastern end of the township. Its dip is uniformly south-southeast, varying a little from an average of S. 30° E. Owing to the zigzag above mentioned the Fenestella shale is found running along the turnpike road, east from Rattlesnake hill, nearly to the head of Dark Hollow, where, though the bend of the road is very slight, beds higher in the series are exposed.

The most remarkable feature characterizing the Hamilton upper shale in Wheatfield township is the presence of a band of iron ore which does not occur in Centre. The shale which carries but a small proportion of iron in most places here becomes heavily charged with it and yields in some spots an ore bed as much as two feet thick. This ore bed and the inter-bedded and containing shales afford many of the fossils found at the typical exposure near New Bloomfield. The bed at the openings yields a brittle fossiliferous ore, characterized by a tendency to break with a square fracture. It is of good quality for its kind, and was mined for the use of the furnace at Duncannon until about 1872, when that furnace was blown out for a time. Since then nothing has been done and the openings have fallen in. The traces of these workings may yet be seen on the land of Messrs. C. Rathvon, C. Dochterman, L. Lickel, and C. Heishley.

Specimens from this bed on the land of Mr. Lickel were analysed by Mr. J. M. Stinson at the laboratory in Harrisburg with the following result :*

Metallic iron,	33.10
Alumina,	7.98
Lime, . . . . .	.30
Magnesia, . . . . .	.80
Phosphorus,	2.50

The Genesee and the Portage shale, VIII.

The Portage shale is well exposed at the mouth of Losh's run by the roadside. Here its characteristic fossils may be obtained.

It also crops out in the roadside about a mile and a half to the southwest on the bank of the south branch of the run. Elsewhere I have not noticed it.

The Chemung group, VIII.

These rocks occupy a broad belt across the middle of the township. They exhibit the usual rounded hilly surface, cut in all directions regardless of the strike by little water

* For full report of analyses see Report M³, p. 35.

courses. The land on this belt is poor as is usually the case on this shales or yellow slate as they are called in the district.

The Chemung shale has a uniform S. S. E. dip except near the fold in Dick's hill, and I have not observed any subsidiary flexures in the township. It is, however, probable that some, at least, of the numerous wrinkles on the east side of the Juniata extend to the west bank.

The Chemung-Catskill beds, VIII-IX.

Section in passage beds between Chemung and Catskill north of Kingsmill.

The following section occurs near the base of the red shales at the top of the hill half a mile north of Kingsmill:

Dip 25° S. 30° E.

Yellowish-green sandstone (with fossils) indicated only by loose stones, (<i>d</i> on map below.)	
Red shale, sandy and micaceous, with green sandstone layers,	85' 0"
Green shale,	3' 6"
Red shale with thin green sandstone,	45' 0"
Green shale,	4' 6"
Red shale, crumbling,	4' 6"
Space covered 50 feet.	
Green sandstone with orange specks,	4' 6"
Yellowish-green shale, needle fracturing,	22' 6"
	<hr/>
	169' 6"

The base of this section is near the top of the Chemung, but I found no traces of a fish bed along the part examined.

Below the base of this section at the brook is a bed of green smooth shale. A bed very similar occurs near the middle of the Linton's Hill section. (See report on Penn township.) Further southward and passing Mr. Smith's farmhouse the ground descends to the road junction, and on the slope is a bed of green shale, *containing well-rounded oval pebbles*, not concretionary, of a greenish-brown sandy shale-stone containing plant relics, (*c* on map.)

At the fork of the road the shale (red and green) dips at 40° S. 20° E.

At a short distance along the west road are found some fossiliferous beds containing brachiopods. (*b* on map.)

The occurrence of the pebbles above mentioned is a noteworthy fact as apparently another indication of shallow water in the district at the time of their formation. That such shallow water or even dry land existed during the deposition of the Chemung rocks can scarcely be doubted by any one who has worked among these beds in Perry county. The great abundance of vegetable relics—planttrags as they may well be called—indicates this. In many places the surface of the sandstones and sandy shales is blackened by undistinguishable traces of vegetable life. Over acres and square miles extend these carbonaceous layers one above another, affording proof of abundant vegetation. That this vegetation was terrestrial may be inferred from the fact that seaweeds are not known to leave similar remains, and we may conclude that the land was at no great distance, because organism so small and frail could not be carried far out to sea without becoming disintegrated and decomposed. Much more minute and detailed study of the rocks must, however, be made before the position and extent of this land or shallow water can be determined. See Fig. 2, Pl. XLVI.

The Kingsmill sandstone, VIII-IX.

This interesting fossiliferous bed enters the township from Watts about half a mile north of the head of Duncan's island. It is not well exposed for some distance from the Juniata, but on reaching the high ground it may be readily recognized as a low stony ridge running about E. N. E. and W. S. W.

Near Kingsmill where one of its best exposures occur, both northeast and southwest of the mill, the bed rock is not seen, but abundant material for its examination is scattered over the fields. It is richly fossiliferous and softer than in many other places. The masses exposed are honey-combed with the casts of fossils which have been removed by solution. Some of these exposures lie in Penn township.

Farther southwest, at the next cross-road, (Linton's hill) is an equally rich fossiliferous exposure of the same sand-

stone. Here the bed rock may be seen in nearly vertical beds. It does not exceed, so far as can be determined, 12-20 feet in thickness, and the fossils are not distributed indiscriminately through it, but occur in certain irregular layers or pockets so that one side of a slab is often a clean smooth sandstone, and the other a conglomerate of shell-casts and flat quartz pebbles.

The sandstone may be traced as a low stony ridge without any conspicuous outcrops, nearly parallel with the road across Dark Hollow, where its presence is indicated about half a mile from the head of the "Loop" on Sherman's creek, by a few loose stones carrying the characteristic fossils. It passes on without any very marked display until it crosses the line into Carroll township.

The section through the Lower Catskill rocks at Linton's hill, which properly belongs to this township, will be found in the report on Penn township. It is placed there in order that it may be in juxtaposition with the Kingsmill section, which is its upward continuation.

The Catskill group, No. IX.

The Catskill rocks compose the whole of the extreme southern portion of Wheatfield township. The eastern part, consists of the Chemung-Catskill beds, ending with the Kingsmill sandstone. These have been already noticed. In the west, however, where the township extends more to the south, it includes almost the whole thickness of the Catskill rocks. The hard lower beds may be seen in the neighborhood of Dellville. They form a barrier to the creek in all its northern excursions, reflecting it as from a revetment wall. One of these beds, the Dellville green sandstone, occurs near Dellville mill. It is a hard massive rock, or rather double layer of rock with a thin parting in the middle composed mostly of vegetable remains. This bed may be traced for a considerable distance over the country, and serves as a convenient horizon of reference among the monotonous red shale and sandstone. It is seen at the foot-bridge a mile west of Dellville, at Dellville, and again on the Little Juniata, near Kingsmill, where its included plant-

bed almost constitutes a thin coal seam. Above this horizon the fossils, which in this part of the county characterize this lower division of the Catskill, and which are described elsewhere have not been found. It is convenient therefore, as a sign of a palæontological not less than of a stratigraphical break.

The only part of Wheatfield township containing the Middle and Upper Catskill is this southwestern corner where Pine hill passes through and forms, for a short distance, its border line. There are several good sections exposed along the creek from Dellville down to the head of the "Loop." At the latter place a complete anticline on a small scale is shown. The presence of several of these in this broad outcrop of the Catskill rocks proves the difficulty of estimating or measuring the thickness of the group in this part of the county.

Copy of an old map of the Susquehanna river.

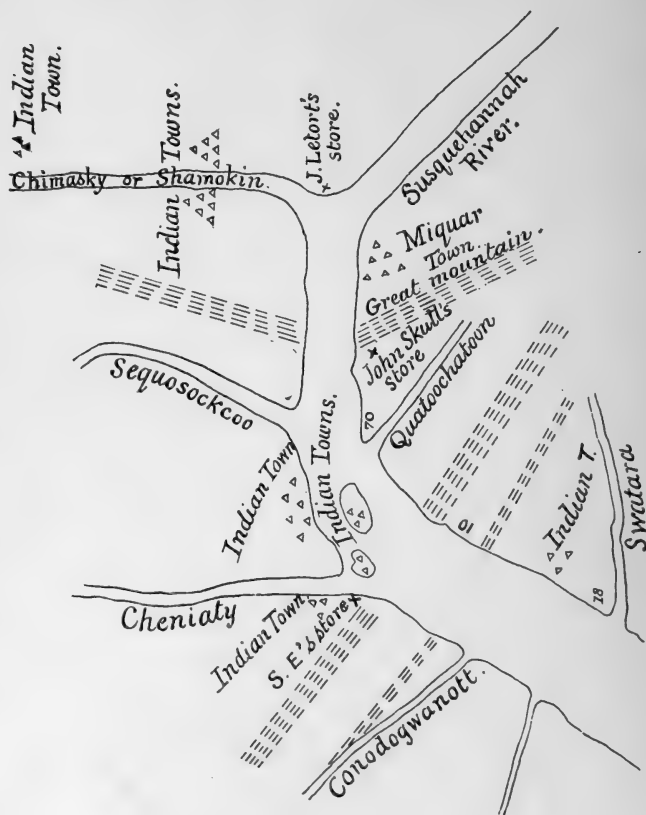
The accompanying copy of an old map of the district of which Perry county forms a portion seems worthy of a place in this report, though not geologically connected with the subject. For the original I am indebted to the kindness of the Hon. C. H. Smiley, of New Bloomfield, who, I believe, obtained it from Dr. Egle, of Harrisburg. (Plate XLVII.)

The surveyor's knowledge evidently diminished rapidly from the southeast toward the northwest. In the former quarter the map is fairly correct. In the latter it is difficult to recognize many of the features of the country.

An Indian town stood on the site of Harrisburg. The Blue mountain and one range of the Cove mountain are delineated. Duncan's and Haldeman's island, at the mouth of the Cheniaty, (Juniata,) are easily identified. The northern may, however, represent Clemson's island opposite Halifax. But further north the distances are contracted and numerous conspicuous objects omitted. The figures, however, seem intended to correct this disproportion, and if the number 70 expresses the miles from the Swatara to

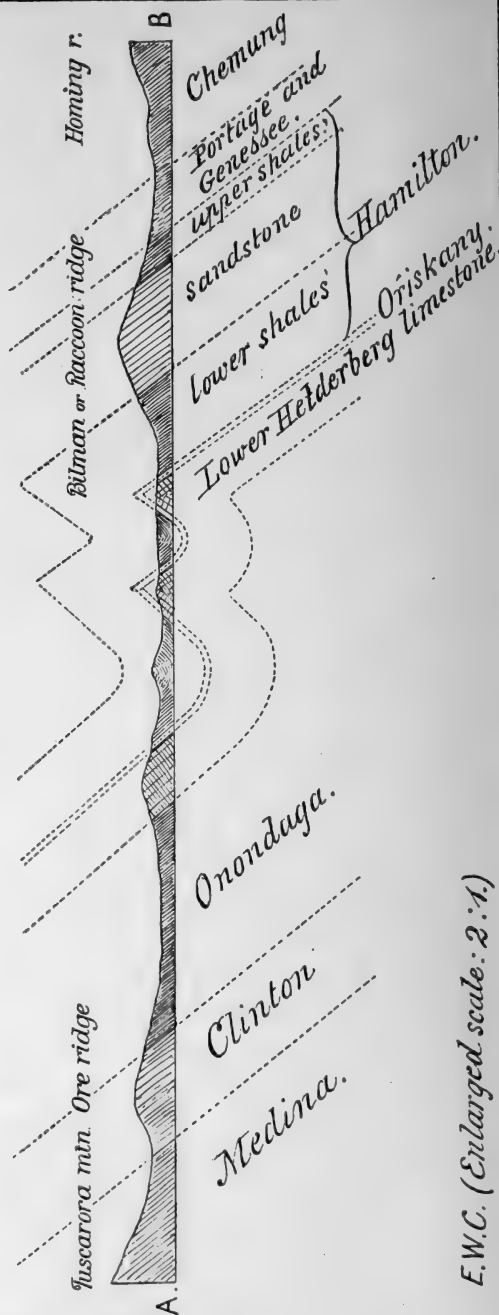
Draught of the Susquehannah River in 1701.

Made by Isaac Taylor, Surveyor of Chester Co.



the great fork at Northumberland, it is nearly correct. The Sequosockcoo and the Quatoochatoon may represent the two Mahantangoes, (east and west.) The "Great mountain" probably stands for the Little mountain and the Line mountain of Northumberland county, and that on the west bank is probably a confusion of all the ridges from Shade to Bald Eagle. The Mikquas' town stood apparently on the site of Sunbury, and the Indian town opposite the island may be on the site of Liverpool.

Section across Tuscarora township, along the line, A-B.



E.W.C. (Enlarged scale: 2:1)

INDEX TO F².

Perry County.

	Page.
Adams' Glen school-house, near fault; ore bank,	86, 98
“ “ 2 m. E. of Landisburg, Spring t.,	340
Adair's quarry, VI <i>a</i> , W. of Centre, Madison t.,	259
Ahl's tannery in Shaeffer's valley, Jackson t.,	229
Allen & Ames' levels,	20
Allen's cove; see the Cove,	226
Alternations of shales and limestone, 29 beds in 10' 7 ¹ / ₂ ,	261
Alluvial deposits, N. end of Miller t.,	275
Amberson's ridge, or mountain,	8, 232, 351, 355
“ “ anticlinal makes Chestnut ridge,	247
Ames, (C. W.),	20
Analysis of sand vein ore, N. of Millerstown,	49
“ “ Clinton fossil ore, V <i>a</i> ,	95, 96
“ “ Marcellus ore, VIII <i>b</i> 1,	99
“ “ Catskill red hematite, IX,	102
“ “ Pocono coal, X,	111
“ “ Newport limestone, VIII <i>f</i> ,	224
“ “ Hamilton fossil ore, VIII <i>c</i> 2, Miller t.,	272
“ “ Pocono coal, X, Duncannon,	292
“ “ Hamilton fossil ore, VIII <i>c</i> 2, Rye t., Seidel's,	314
“ “ local Hamilton fossil ore, VIII <i>c</i> 3, Wheatfield t.,	391
Andersonburg, in Madison t.,	5
Anderson's run,	24
Andesville, (Loysville,) in Tyrone t.,	5
Anticlinal valleys enumerated,	29
“ arches described,	33, 81, 83
“ “ of Chestnut ridge, shows V <i>a</i> well, Jackson t.,	231
“ “ “ main axis of Bloomfield vale and Half Falls mtn.,	231
“ “ beautifully shown at Bistline's mill,	232
“ “ of Amberson's mtn. and Chestnut ridge, Madison t.,	247
“ arches, five in Madison t., lifting V to VIII,	249
“ “ four in Limestone ridge, E. of Ickesburg, Saville t.,	321
“ “ of Tyrone t.,	367
“ “ of Half Falls mountain,	381
Aqueduct,	23
Arches—See Anticlinal.	
Archimedes' screw for pumping water,	193

	Page.
Area of Perry county,	2
Arnold's farm,	183
Ayl's quarry, in VI,	161
Bailey's run, Miller t., drains basin bet. Mahony and Limestone ridges,	265
" " at foot of Stony south steep of Buffalo hills,	270
" " fine scenery,	270
Baileysburg, (Old Caroline furnace,) Miller t.,	4
" bluffs of VIII f,	274
Ballast for roads from VIII b 5, near Little Germany,	341
Barger's run valley,	17, 26, 29
Barnett's farm in Centre t. shows VIII b,	190
" (Geo.) Marcellus ore diggings, at Bloomfield,	193
" rocks, S. of New Bloomfield, best exposes VIII b 5,	196
" mill, Centre t.,	206
" brick clay, near New Bloomfield,	208
" sand pits, VII, pebbly,	208
Barren (of fossils) shale VIII c 3 (c), 200' Centre t.,	69
" green shale, VIII c 3 (b,) 200' \pm ,	205
Basins (geological) described,	31
Baskinville in Penn t.,	4
Beach drift of dead shells in Kingsmill SS.,	291
Bear's quarries, VI, largest in Perry co.,	160, 161
Bear ponds, head of Patterson's run, Toboynne t.,	349
Beavertown in Jackson t.,	5, 351
" narrows, on Houston's run, Jackson t.,	230
" " fine exposures,	232
Beggar's run, drains to Bridgeport, Sherman's cr.,	333
" " in Spring t.,	344
Bell's hill (Bell's Cop,) Spring t.,	335
" " made by VI limestone,	337
" " abandoned ore mines, S. W. New Germany, VIII b,	341
" " limestone (VI,) Tyrone t.,	374
" " has no VII on it,	374
Berry, (J.,)	161
Berry's mountain, described,	10
Big river, local name for Susquehanna, Watts t.,	382
Bilman ridge, Savage t., VIII c 2,	321
" " high and rugged eastward, flattens out westward,	321
" " long, romantic gorge made by Buffalo cr.,	321, 327
Birdseye ore,	160
Bistline's mill, Madison t., Jackson t. line,	57; 232
" " near Andersonburg,	253
" " section of V, a, b, 1262', Madison t.,	255
Bitman's ridge, VIII c 2 described,	15
Bituminous limestone, VI a, Millerstown,	58, 180, 218
Bixler's mills, Savage t.,	326
" quarry in VI b,	259
Black cherty limestone beds of VI c,	62
" " " abound with silicified crinoidal joints,	62
Black shale, (Marcellus,) see VIII b,	64

	Page.
Blaine in Jackson t.,	5,351
“ high knoll, synclinal, of VI,	234
Block ore of V <i>a</i> , described,	48,160
Bloomsburg red shale of I. C. White's report G ⁷ ,	
“ “ “ V <i>b</i> , bottom member of Onondaga formation,	51
“ “ “ fossiliferous only in a few places,	51
“ “ “ no Clinton form as yet seen in it,	51
“ “ “ 830' thick in Madison t.,	255
Bloomfield (see New Bloomfield) in Center t.,	4
“ valley anticlinal,	29
“ branch of Little Juniata river,	177
Bloomfield sandstone, in V <i>b</i> , Onondaga,	54,233
“ “ makes a low ridge along the valley,	179
“ “ 42' thick in Landisburg section, Tyrone t.,	372
Blue limestone beds of VI <i>a</i> best for lime,	259
“ well exposed in Madison t.,	259
Blue mountain described,	1,8
“ “ anticlinal spur splits Henry valley near west end of Jackson t.,	231
“ “ crest in Rye t. a double line of ragged, broken, notched outcrops, 500' apart,	310
“ “ flat outcrops of vertical V <i>a</i> 1 beds,	311
Bluffs—See Cliffs.	
Bluffs of Chemung, VIII <i>f</i> , at Montebello furnace,	72
“ “ “ at Newport,	72
Bluff of VII above Adam's Glen, S. H., Spring t.,	338
Borroll, (Wm.),	165,167
Bossardville limestone of I. C. White, VI, described,	58
Bower mountain,	8
“ “ crest at road in Jackson t. 950' above Shaeffer's valley; 1350' above Landisburg; 2000' ± A. T.,	8,229,231,355
“ “ in Madison t., all wooded, but one farm on top,	249
Bower's (Mr.) three warm springs, Spring t.,	348
“ “ “ temperature 65°, 61°, 60° F.,	348
Boulders brought down by river ice,	167
“ of white chert in Buffalo valley, 20' to 30' above present bed of Little Buffalo creek,	200
“ of trap piled up for a width of 500', Rye t.,	316
Boyd's ridge skirts N. side of Bower's mtn., Toboyne t.,	351
Bradford co. fossil found in Perry co.,	328
Breccia limestone in V <i>b</i> , variegated shales, Loysville, Tyrone t.,	373,374
Brick-clay and sand in Center t. described,	208
“ in Juniata t.,	237
Bridgeport in Spring t.,	5
Bridgeport sandstone in lower part of red shales, V <i>b</i> , described as a local deposit,	57
“ “ at Bistline's mill, 5' thick, underneath 200', and overlying 500' of red shale, V <i>b</i> ,	58
“ “ makes Quaker hill in Spring t.,	338
“ “ crops out frequently in Tyrone t., especially on sides and top of ridge in Kennedy and Green valleys,	373
“ “ 12' thick, makes rugged terraces,	373

	Page.
Bridgeport sandstone very well exposed at Egolf's mill, Tyrone t.,	373
Brown's (S.) house,	85,207
Brown's run, Toboyné t.,	24,349
" " valley, synclinal,	29
" " mouth at Mt. Pleasant in Jackson t.,	230
Brown hematite iron ore of Marcellus VIII b 1,	96
Brownell's lime-kiln, VI,	160
Brunner, (G.),	73,291
Brunner (W.) brick-clay, near N. Bloomfield,	90,207,210
Buck hills, near Blain, Toboyné t.,	351,355
Buck's (Middle) Valley ridge, Buffalo t.,	147
Buckwheat valley, Tuscarora t.,	361,365
Buffalo township geology,	147
Buffalo creek; shows E. dip of rock trough,	17,25
" " sinuous in Oliver t.,	278
" " in Saville t.,	319
" " gap through VIII c 2,	327
Buffalo hills, VIII c 2,	15,67
" " in Centre t.,	198
" " in Miller t., N. slope gentle and cleared; S. slope scarp- ged, steep, over Bailey's run,	270
" " in Oliver t., north of Limestone ridge,	277
Buffalo mill, Madison t.,	254
" " section, V b, Saville t.,	324
Buffalo mountain described; all woods,	10,245
Buffalo mountain cove,	148
Buffalo (Raccoon) valley, broad in Saville t.,	321
Building sand—See Sand.	
Building stone, ore-sand rock, V a, Waggoner's mill,	231
Burn (Mr.); Burn's valley, Toboyné t., in IV,	159,353
Calcareous green shales of V,	45
Canal levels,	20,23
Carbonate iron ore of VIII b 1,	194
Carlisle road shows the Perry county fault,	85
Caroline furnace, Baileysburg, Miller t.,	4
Carroll township described,	157
Casts of fossils filled with ochre; see Fossils,	74
" " in the Kingsmill sandstone, Wheatfield t.,	393
Catalogue of plants growing in the county, Ch. VI,	113
Catskill formation; see IX,	72
" " assumed base, Delville sandstone,	77
Cave of Simon Girty the outlaw,	151
Caverns in VI, in Saville t.,	325
Cedar (Cissna's) run, section V b, Madison t.,	256,257
Centre township described,	169
Centre, in Madison t.,	5
Centre mills, in Madison t.,	253
" " Tudor's section of VIII b,	261
Centre run enters Sherman's cr. near C. mills,	253
Centre section, 262', V b, Madison t.,	257,258

	Page.
Centre valley, between Chestnut ridge and the ridge of V; the best farm land in Madison t. made by sand from VII,	249
Centreville, Toboyne t.,	5
Charcoal furnaces,	102,387
Chemung formation—See VIII <i>f</i> .	
“ fossils useful in working out the faults,	83
Cheniaty (Juniata) river,	395
Chert beds—See VI, 4, 5.	
Chestnut ridge, Jackson t., V <i>a</i> , begins at Waggoner's mill, near center of Tyrone t.,	231
“ “ in Madison t., described,	247
Chestnut hills, in Jackson t., between Sherman's cr. and Houston's run; ends at Beavertown, V <i>a</i> , iron SS., and ore SS.,	230
“ “ near Centre, Toboyne t.,	351
Cissna's (Cedar) run, section V <i>b</i> , Madison t.,	256
Clark's mill; fossils,	182,374
Clark's Mill beds; see VI <i>b</i> , Lewistown shales,	59,181
Clark's (Rob.) farm,	256
Clay; see Brick clay,	237
Clemson's island opposite Halifax,	395
Cliffs—See Bluffs.	
Cliffs of Pisgah hill, VIII <i>c</i> 2,	157,162
“ of VII, very fine, Centre t.,	190
“ high on both sides the river, Oliver t.,	278
“ of VIII-IX, in loop of river, below Milford,	282
Clinton formation—See V <i>a</i> .	
“ fossils in sand vein ore bed, Tyrone t.,	371
Clouser, (A.,) Centre t.,	183
“ ore banks south of Newport,	95
“ “ “ Miller t., 4th outcrop of VII,	268,269
“ iron works, Oliver t.,	279
Coal measures,	38
Coal seams, one inch thick, found by Mr. Hockenberry, in Horse Valley slates, III <i>a</i> ,	352
Coal vainly sought, Marcellus black shale, VIII <i>a</i> , near Laurel Grove, 90,107,108	
“ “ “ also in gray shales, VIII <i>b</i> 5, near New Germany, found by Mr. Smith, 3 inches thick,	341,342
“ “ “ also in VIII <i>c</i> 1 (!) Spring t.,	343
“ seams, thin, in the bed of the Juniata,	108,109
“ layer in Dellville SS., base of IX,	289,395
“ “ in Catskill formation, No. IX,	109
“ bed, 3' thick, in Buffalo mtn, No. X,	153
“ bed, in Berry's mtn., No. X,	155
“ “ at Duncannon; 10", 24", 30",	292
Cochran, (R.,)	95,217
“ new ore mine, 1 m. N. of Millerstown,	363
Cocalamus creek, Greenwood t., how it runs,	13,26,213
Concord, Toboyne t.,	349
Conococheague mountain, No. IV, Jackson t.,	8,230
“ “ Madison t., 248,249; Toboyne t.,	354,355
Contorted fossils; see Fossils,	70

	Page.
Cook & Petermann's, Hamilton fossil ore,	100
Cook, (P.,) old mines, Miller t.,	205, 272
Copper ore,	322
Corniferous character of Clark's Mills limestone topmost beds. VI b,	59
" limestone formation of New York, possibly coeval with Oriskany in Pa.,	63, 64
" " improperly recognized in the greenish limestone beds under VIII b 1,	191
" " not to be identified with VIII b 2, 3; no Corn. Lim. fossils to be found in them,	260, 261
Cove creek,	26
Cove mountain, Penn t., described,	9, 10, 285
Cove in Penn t., well cultivated,	293
Cove of Hunter's run, or Buffalo mountain,	148
Cranby hill, VIII c 2,	15
Crawley anticlinal,	347
Crawley hill, VIII c 2,	81
" " Little Germany fault,	90
" " VIII c 2 fossil ore outcrop; unproved,	100; 205
" " east end in Centre t.,	201
" " unites with N. Furnace hill, at Beggar's run, Spring t., 343, 344, 345	
Crest of Blue mountain, Rye t.,	311
Crumpling of the crust of the earth,	41
Cumberland Valley trap dyke,	294
Dachterman's farm,	100
Danville fossil ore beds, at Millerstown v., a 3,	323
" " in shales under ore SS., no trace of them in Tyrone t.,	371
Dark Hollow, Kingsmill SS., Wheatland t.,	390, 394
Dawson, (Dr. J. W.,) of Montreal,	65, 341
Delville, in Wheatfield t.; mill,	4; 389, 394
Delville green sandstone, assumed base of IX,	75, 77, 394
" " why green,	77, 78
" " 20' thick at Judge Junkins', Carroll t.,	166
" " has coaly layer; top of Kingsmill section, Penn t.,	289; 395
" road through gap between Dick's hill and Round Top,	390
Deposits in the sea,	37
Dick's hill, VIII c 2; faulted,	16, 67; 86
" " fossil ore of VIII,	100
" " in Wheatfield t.—called Rock hill in Carroll t.,	162
" " highest ridge in Centre t.; only one gap,	202, 203
" " in Miller t.,	271
" " east end cut off by fault,	381
Dick's Hill Bridge, a connecting ridge from Dick's hill to Round Top,	390
Dip gentle in Sandy hill,	67
" 45° in Buffalo and Dick's hills,	67
" 40° in Dick's hill,	86
" 45° at Little Germany fault,	90
" 65° N., in X, Berry mtn., Buffalo t.,	152
" steep in Rock hill, N. side; 30° S. side,	162
" vertical nearly in Centre t., zig-zags of VI a,	180
" overthrown sometimes in Centre t., VI a,	181

	Page.
Dip 30° N. N. W., Centre t., Clark's mill, VI b,	181
" 90°, Centre t., Long's ore bank, VIII b 1,	194
" 92° S., Centre t., Barnett's mill,	206
" 30° N. N. W. Centre t., on L. Buffalo creek,	206
" 60° N. 300 yards below Newport bridge,	225
" 15° Jackson t., gap of Sherman's cr. through Chestnut ridge in the rocks of V a,	232
" 60° Jackson t., half a mile west of the gap,	232
" steep N. and S. in Liverpool t., VI,	242
" 70° along N. br. of Barger's run for 1½ miles, making VIII-IX and IX 6000' to 7000' thick,	244
" 20° to 25° N. N. W. Madison t., Centre quarries, VI a,	259
" 20° to 50° N. N. W. in limestone quarries of VIII b,	262
" 40° west of Centre mills, in same,	262
" 90° Oliver t., ore bed of VIII b 1,	279
" 75° N. N. W. between Newport and Clouser's mines,	279
" flattens to 25° and 30° at Inoculate run, Oliver t.,	279
" 100°+ N. N. W. overthrown, in Penn t., X,	285
" 40° S. 20° E. Penn t., Kingsmill,	287
" 35° S. 20° E. at Kingsmill,	289
" 90° nearly all along Blue mountain, Tyrone t.,	370
" 45° N. N. W. on McCabe's run at Egolf's mill,	373
" 40° to 50° in Half Falls mountain,	380
" 30° to 90° in short distance along crop of VIII c 2 in Wheatfield t.,	389
" 30° SS. E. uniformly along crop of VIII c 3, along Dick's hill, Wheat- field t.,	390
" 25° S. 30° E. in Kingsmill section, Wheatfield t.,	392
" 40° S. 20° E. in VIII-IX shale, Wheatfield t.,	392
" 90° nearly in Kingsmill SS., Wheatfield t.,	394
Distortion of fossils,	41
Dividing mountain, Toboyne t.,	356
Dochterman, (C.,) mine on VIII c 3, local ore,	390, 391
Dolerite; see Trap dykes,	301
Dolomitic (magnesian) limestone absent from Center t.,	180
Donally's mills in Tuscarora t.,	4, 15
Dorran's run. Center t., exposes VIII b 5,	196
Dorran's gap, very picturesque,	199
Dorran's narrows, VIII b fossil ore crop,	195, 204
" " sand of VII,	209
Doubling hollow in Cumberland county,	229, 370
" " road over Blue mtn., Madison t.,	249
Drumgold's tannery, Sherman's cr., Carroll t.,	68, 164
Dry land in palæozoic times,	63
Dry saw-mill on the Susquehanna river, two miles N. of Liverpool,	244, 245
Duncan's island, Wheatfield t.,	295, 393
Duncannon, in Penn t.,	4
" hill, of IX,	78
" Iron Company: furnace,	100; 391
" coal bed in X,	292
Dunn's ore banks, Spring t., VIII b 1,	341
Egle, (Dr.,) of Harrisburg,	395

	Page.
Earth crust subsides,	37
East Duncannon trap dyke,	298, 384
Egolf's mill in Kennedy valley, Tyrone t.,	57
" saw-mill, Tyrone t., good exposure of Bridgeport SS.,	373
" ore of V, very fossiliferous; cross Tyrone t.,	50; 371
Elevation and subsidence; see Emergence,	306
Elliottsburg in Spring t.,	5, 14, 338
" valley, part of vale of Bloomfield,	331
" red shale valley, V b, between Limestone ridge and Mahony ridge,	335
" outspread of VI limestone,	337
Elvans; see Trap dykes,	79
Emergence; see Elevation,	63
" or shallow water shown by Kingsmill SS., &c.,	76
" in Rye t. temporary, (VI, VII, VIII b,)	309
" in Chemung age, shown by pebble bed, Wheatfield t.,	393
Enslow's mill, Sherman's cr., mouth of Houston run, Jackson t.,	230
" " road section of V b (801'),	233
Erosion of river beds,	20
" of Central Pennsylvania,	21
" of Horse valley, 25,000',	38
" by the Juniata river,	39
" from Perry co. 5,000,000,000,000 cub. yds. of rock, 39;—one 5,000th of a yard per year,	40
" shown by white chert bowlders in Little Buffalo Creek valley, 30' to 50' above the present water level,	200
" of gap, one mile west of Little Juniata gap, in Mahony ridge, worthy of study,	200
" of vales in middle member of VIII c 2, making zig-zag narrows, as at Montebello,	203
" by the Juniata river, in Howe t.,	223
" see Brick clay, 1 m. W. of Juniata,	237
" of Buffalo creek, at Bilman Ridge gap, VIII c 2, curious and beauti- ful instance of folded structure affecting topography,	321
" of Sherman's creek, Tyrone t.,	367
" of valley of McCabe's run, shown by gravel deposits 60' to 80' above bed of run, Tyrone t.,	369
" between ridges of iron SS. and ore SS., Tyrone t.,	370, 371
" of Susquehanna river, in Watts t.,	377
Error of thickness assigned to Genesee formation,	71
Excavation by rivers; (see erosion),	39
Fairview, in Toboyne t.,	5
Falling Spring, Spring t.,	162, 338-9
" " fed by two springs, (out of VII,) &c.,	339
" " temperature, 55° F.,	348
" " <i>Stromatopora</i> bed (VI b) well exposed,	337
Farming in Centre t.,	173
Fault of Perry co., described in Ch. IV,	35, 81
" throws 2300'; 6510',	85; 86
" does not reach Blue mountain,	86
" doubled in Half Falls mountain,	87
" measured by formations 4075' (5700'),	88

	Page.
Fault in Half Falls mountain, 600' +,	88
“ cuts off VIII fossil ore,	100
“ in Carroll t. 1200' throw,	159
“ in S. W. end of Spring t. described,	345
“ in Watts t., Half Falls mtn.; throw, say 800'; dies out 3 miles or so east of river,	380
Fault of Little Germany described,	89
“ throws 400' to 500' at Knob, Spring t.,	343
“ in Spring t. described,	346-7
Fault intermediate, throws 200' to 300',	91
Fishing creek, Penn t.; Rye t.,	19, 283, 303
“ “ run described,	26
Flagstones from IX red SS., Liverpool t., good,	244
Flags, in middle of VIII c 1, an exceptional occurrence (in Saville t.),	326
Flint shale members of VI described,	59
Flint gravel soil of VI, Centre t.,	59, 173
Flint beds of VI, make fine ridge and rocky soil, narrow belt, Liverpool t., 242 “ “ section, Tuscarora t.,	364
Flint of cornif. lime. for. of New York, not to be found in the fine exposures of Madison t. (No corn. lim. fossils,)	260-1
Folds in limestone 41; in VI, VII, Centre t.,	185
“ in VIII <i>d e f</i> belt of Watts t. numerous,	383
Foose, (J.), of Duncannon,	292
“ tunnels for coal in VIII c 1, Spring t.,	344-5
Forest trees,	175
“ described in Chapter III,	43
Formations tabulated, indexed—See end of Index,	36
Fossils—See end of Index for list of genera and species.	
Fulling Mill gap, Centre t.,	204
Furnaces in Perry county,	102, 387
Furnace hills, N. and S., VIII c 2,	15
“ “ beautiful scenery, Centre t.,	202
“ “ unproved VIII c 2 fossil ore crop,	205
Fossils distorted by pressure,	41
“ of Chemung (VIII <i>f</i>) rarely well preserved,	70
Fossil casts full of oxide of iron, (VIII-IX,)	74
“ “ in Oriskany, (VII,)	190
“ “ make up the Newport limestone, (base of VIII <i>f</i>),	224
“ “ of lamellibranchs crowded in K. SS., Penn t.,	287
“ “ of dead drifted shells on breach of K. SS.,	291
“ “ of <i>Leperditia alta</i> cover Bloomfield SS. slabs,	372
Fossils help to show the lines of fault,	81, 83
Fossils of Clinton and L. Helderberg commingled,	51
“ of Oriskany found as high as Hamilton,	314
Fossils of V <i>a</i> ; abundant in ore SS.; scarce in lower shale; not frequent in iron SS.; abundant in upper shale,	50
“ of iron SS. (V <i>a</i> 2) in Madison t.,	254
“ of sand vein ore bed, Tyrone t.,	371
“ of V <i>b</i> scarce in the red shale,	53
“ “ “ in Jackson t. very interesting,	233
“ “ “ red shale. Buffalo mills, Savage t.,	324
“ “ “ “ seldom to be found elsewhere,	324

	Page.
Fossils of VI; Brownall's lime-kiln,	61, 160
“ “ not seen in Watts t.,	378
“ “ VI b in Centre t.,	180
“ “ “ “ coral masses easily cleansed,	338
“ “ VI c d, flint shales, scarce,	62
Fossils of VII, casts, Centre t.,	190
Fossils of VIII a, Corniferous limestone of N. Y. nowhere to be seen in Perry county,	261
“ “ VIII b 3, at Adam's Glen and Falling Springs,	340
“ “ VIII c 1, scarce in Centre t.,	197
“ “ “ “ nearly absent in all Perry county,	343
“ “ VIII c 2, Centre t., <i>Paracyclas</i> ,	203, 272, 314
“ “ VIII c 3, abundant, bright red or black, clearly marked,	69, 205, 206, 383
“ “ “ “ abundant and well preserved in Saville t.,	328
“ “ VIII d e f, hard to find in the outcrops of the Juniata river bends, Miller t.,	274
“ “ VIII e, Portage, Carroll t.,	164
“ “ VIII f, Chemung, rarely well preserved,	70
“ “ “ “ plants, in upper red sandy beds in Saville t.; but not in the southern townships,	328, 393
“ “ VIII-IX, Kingsmill SS., 73-74; abundant, good, in Carroll t., 165; in Liverpool t.,	159, 245
“ “ “ “ nine beds in 500',	290
“ “ IX, (base,) Delville SS.; plants,	77
“ “ of Centre mills to be described in Vol. 2,	262
Fossil ore of V a in section,	46
“ of upper shale absent,	49
“ double at Egolf's,	50
“ described; soft at outcrop,	93, 94
“ at Marysville, 95; in Kennedy Valley,	96
“ in Greenwood t. described,	217
Fossil ore of VIII c 2, Hamilton SS.,	99
“ on south slope of Rock hill, three beds, Carroll t.,	163
“ McCormick & Co., Girty's notch,	382
“ ore trials in Centre t.,	204, 205
“ no trace of it in Howe t.,	223
“ mined extensively in Miller t., SS., Mahony ridge,	272
“ upper bed, <i>Fenestella</i> shale, (Rye t.,)	315
“ middle bed, 30' feet lower, is probably Little mountain bed,	315
“ never opened in Spring t.,	345
Fossil ore of VIII c 3; overlying Ham. SS., Centre t.,	69, 204
“ 28" in Seidel's tunnel, Rye t.,	314
Gaps; see Narrows,	171
“ of Sherman's creek through Pisgah hill,	157
“ in Blue mountain,	159
“ through VIII c 2, in Centre t.,	198
“ one mile west of L. Juniata gap through Mahony ridge, has only a brook in it,	200
“ through Buffalo mountain in Howe t.,	226
“ of Beavertown narrows on Houston's run,	230

	Page.
Gaps; none in Bower mountain,	231
“ of Sherman creek through Chestnut ridge,	232
“ numerous through Chestnut ridge on account of thinness of iron SS. and ore SS. in Madison t.,	247
“ of Susquehanna now at Liverpool, fine,	241
“ in Buffalo hills, Miller t.,	270
“ of Buffalo creek, through Bilman ridge, (VIII c 2,) in Saville t., pic- turesque,	321
“ in mountains in IV, Toboynne t.,	356
Gap in the series of formations,	Note to 38
Garber's quarries of VI, Spring t.,	161, 337
Garling, (W.),	189
Genesee formation—See VIII d.	
Gibson, Chief Justice,	157
Geological structure, 31; history,	35
Gibson's (F.) old quarry in VI b, Spring t.,	337
“ ochre bed,	101
“ gap through VIII c 2 ridge, Carroll t.,	162
Gibson's rock, end of Rock hill, Carroll t.,	83, 101, 157, 162
“ “ road, crossed by fault,	85
Girty's notch on the Susquehanna river, Buffalo t.,	89, 150, 378, 380
“ “ fossil ore of VIII c 2,	100, 382
Girty, (Simon,) the outlaw; his cave,	151
Glen school-house, 2 m. N. of Bridgeport,	338
“ “ exposure of 40' of VIII b 3, same fossils as Falling Spring,	339
Gradient of Susquehanna, 1'.82 per mile,	19
“ of Juniata river, about 2' per mile,	23
Gravel 60' to 80' above level of McCabe's run,	369
“ flood plain 30' to 40' above Susquehanna river,	378
Graveyard, old, in Miller t.,	267
Gray shales of V b, in Penn t., described,	55
“ “ no gypsum known in Perry co.,	55
Great Horseshoe dyke, Penn t.,	296
“ “ “ in Rye t., 200' (?) wide (500' crop,)	316
Green sandstone,	77, 78
“ shales of V, bottom of red shale,	45
“ spots in red shale,	53
“ color of VIII c 1 flags, conspicuous in Saville t.,	327
“ Park in Tyrone t.,	5
“ “ road, VIII b 3 exposed 75', Spring t.,	340
“ run drains past Oak Grove furnace to Sherman's cr. 3 m. W. of Gib- son's rock, Spring t.,	333
“ “ valley, synclinal,	29
Green valley, Tyrone t.,	373
Greenwood township described,	213
Grier's Point (Keystone) Fenwick valley,	29
“ “ in Rye t.,	4
Grier, (S.),	165, 167
Grier's (W.) sand from VII, near N. Bloomfield,	209
Gypseous beds of V b wanting,	52
Haldeman's island, Watts t.,	377, 384

	Page.
Half Falls mountain made by converging ridges of VIII c 2,	380,381
Half Falls mountain, VIII c 2,	272
“ “ “ fossil ore,	100
“ “ “ fault, throws 600'±,	88
Hall's quarries (VI) N. of Blain, Jackson t.,	233
“ “ furnish most of the lime of West Perry co.,	234
Hamilton formation, (see VIII c) 900' thick,	66
“ lower shales, (see VIII c 1,)	197
“ sandstone, (see VIII c 2,)	15
“ upper shales, (see VIII c 3,)	205
Harrisburg, Indian village,	395
Heishley (C.) fossil ore mine of VIII c 3,	390,391
Henderson, (Dr. A. A.,)	294
Henry valley, upper part of Shaeffer's valley,	9,229
“ “ split by spur of Blue mountain, W. end Jackson t.,	231
Hentzel's narrows, (VIII c 2,) Center t., beautiful,	199
“ “ sand of VII,	209
Hicks' fossil ore exposure, VIII c 2, very fossiliferous; same fossils as at Marysville,	163
Hill ranges of VII described,	12
Hill ranges of VIII c 2 described,	15
Hockenberry's (Job) coal in Horse valley, Toboyne t., in Utica slate, only 1 inch thick,	108,352
Hoffman, (S.,)	218
Hominy ridge, Juniata t., VIII f,	71,235,328
“ “ Chemung shales, poor land, VIII f,	71
“ “ Tuscarora t., VIII f,	362
“ “ south side, Kingsmill SS., (VIII-IX,)	74
Honeycomb ore, (VIII b 1,) Kingsmill,	97,393
Horse-Shoe bend of Susquehanna—Cove,	292
Horse-Shoe trap and dykes—See Great and Little.	
Horse valley, in Jackson t., Toboyne t.,	29,229,351
“ “ east end split by Locking mountain,	230
Horse Valley run, in Madison t.,	253
“ “ “ gap, Toboyne t.,	354
“ “ P. O., Toboyne t.,	5
Horting's run, bet. Centre and Miller, into Juniata,	169
Houston's run, Jackson t., bet. Bower mountain and Chestnut hills,	24,230
“ “ in Toboyne t.,	351
“ “ valley synclinal,	29
“ “ gap, Toboyne t.,	356
Hudson River slate formation No. III b,	43
Hunter's run, 26: Cove,	19,148
Huling's (Ab.) island,	377
Hydraulic lime wanted in VI,	58
Ickesburg, in Saville t.,	5,321
“ valley of V a, between Conoco mtn. and VIII ridge, in Madison t., (anticlinal,)	250,251
“ limestone,	325
Inoculate run, 15: VIII c 3,	68
“ “ in Oliver t.,	279

	Page.
Inoculate bridge, outcrop of VIII c 2, iron ore, Centre t.,	204
“ “ fossil ore, VIII c 2,	100
Inoculate ridge made by VII, in Miller t.,	268
Intermediate fault; see Fault,	91
Iron furnaces,	102
Iron ore beds described in Chapter V,	93
“ of V a, at Millerstown, only sand vein worked,	363
“ of V a—See V a.	
“ of VII wanting all over Perry county,	101, 187
“ on top of VII, in Centre t., at Juniata furnace, Ruder's, Garling's, Powers' &c.,	187, 188
“ on top of VII, in Centre Mills section, Madison t.,	262
“ of VIII b 1, Marcellus brown hematite,	64
“ “ “ Clouser's, Ruder's, Long's,	96, 97
“ “ “ in Centre t. described,	191
“ “ “ thick when the limestone is thin, and v. v.,	193
“ “ “ hematite at crop, carbonate below,	194
“ “ “ fine display on road, Madison t.,	263
“ “ mined considerably on hill opposite Oak Grove furnace, Ty- rone t.,	375
“ “ 2' thick in VIII c 3, local to Wheatfield t.,	391
“ “ “ in white and black clay, vertical, Oliver t.,	279
“ “ “ diggings in Spring t.,	340
“ “ “ —See also VIII b 1.	
“ of VIII c 2, Hamilton fossil ore,	69
“ “ “ —See also VIII c 2.	
“ of VIII e, top of Portage, worthless,	101
“ in IX thin seams of red hematite, Rye t.,	102, 316
“ in X Pocono, with coal, poor,	102, 293
Iron ridge ore banks,	14, 98, 197
Iron sandstone—See V a 2.	
“ “ of Bower mountain,	367
“ “ crop high on Blue mountain,	370
“ “ “ makes visible terrace,	370
“ “ “ thicker in Tyrone than further north,	370
Ironstone ridge=Great Horseshoe trap dyke.	
“ “ in Penn t., 296; in Rye t.,	316
Islands in the Susquehanna river,	241
Jackson township described,	229
Juniata=Milford,	4
Juniata township described, generally cultivated, hilly N. part wilderness,	235
“ “ entirely composed of VIII f and IX,	237
Juniata river described; “Cheniaty,”	17, 22; 395
“ “ carries 1,000,000 cubic yards of rock down annually,	39
“ “ great bend,	235
Juniata bridge, (trap dyke,)	300
Juniata furnace, 184; ore bank, (VIII c 2,)	100, 192
“ “ “ large and abundant,	195
Juniata furnace gap, VIII c 2, Center t.,	198
Junkin's (Judge) section in Carroll t.,	166
Junkin's ridge made by Kingsmill SS.,	165

	Page.
Kennedy's valley; ore; Tyrone t.,	373; 96
Kepner's (H.) sulphur spring, Madison t.,	262
Kern's quarries, limestone VI, Jackson t.,	234
Keystone in Rye t.,	4
Kingsmill, 2 m. N. W. of Duncannon,	73, 285
Kingsmill section, VIII-IX, Penn t.,	287, 289
" " " in Wheatfield t.,	392
Kingsmill sandstone—See VIII-IX.	
" " " 20', best exposed, low ridge, Wheatfield t.,	393, 394
Kingsmill shales, described,	77
Kittatinny mountain; (see Blue mountain,)	8
Knob of Blue mtn. synclinal, over Three Square hollow in Cumberland county,	231
Knob of VII at Oak Grove furnace,	339
Knob of VIII c 1, made by Little Germany fault,	343
Knob of VIII c 2, Mahony ridge, west end, Spring t.,	344
Lamb's gap in Little Mtn., Rye t., 4 m. west of Marysville, shows VIII c 2 fossil ore,	314
Landisburg, Tyrone t., (740' A. T.,)	5, 25, 229, 351
" ore of VIII b 1,	340
" section of V b var. shales (327')	372
" limestone prongs,	374
Laurel run (Murray run) drains Henry valley, Jackson t.; synclinal; Madison t.; Toboynne t.,	9, 24, 29; 230; 253; 351
Level ore,	322
Levels on canal and railroad,	20, 23
Level of top of Bower mtn., 2090' \pm A. T.,	229
" of Landisburg, 740' A. T.,	229
" of Shaeffer's valley road, 1140' \pm A. T.,	229
Lewistown limestone—See VI a Lower Helderberg.	
Liberty hall, Greenwood t., Liverpool t.,	3, 244
Liberty valley, continuation of Raccoon valley bet. E. Tusc. mtn. and Conoco mtn.,	249
Lickel's (L.) farm; fossil ore, local in VIII c 3,	100, 390, 391
Lime and its uses on land,	103
Lime for the region made from Liverpool t. quarries,	242
Limestone ranges—See VI a.	
Limestone formations,	38
Limestone ridge, 13, 14; ends in Buffalo t., 149; in Centre t. described, 169; in Oliver t., 277; in Tyrone t.,	374
Limestone, Marcellus, VIII b,	64
" abundant in Spring t., zigzags of VI a,	333
" and shale alternations, Tudor section,	261
" beds in V b var. Sh. very thick and heavy, 1½ m. S. W. of Loysville, Tyrone t.,	373
" broken up and re-cemented,	373
Limit of Clinton and Onondaga (V a, V b) placed at top of Sand vein ore bed,	46
Linton's hill, 3 m. W. of Duncannon,	73
" " section, Kingsmill SS., &c., (see VIII-IX,)	290
" " in Wheatfield t.,	393

	Page.
Linton's mill,	287
Little Bridgeport valley, anticlinal,	29
Little Buffalo creek, 17, 25; valley, 29; gap, through VIII c 2, Centre t., great debris of white chert,	199
Little Germany fault, throws 1150' (1600,) 89; described, 201; throws 1250' in Centre t., 210; throws VIII c 1, 400' to 500' at Knob, 343; in Spring t., described,	346, 347
Little Germany village, nestles picturesquely in valley between Mahony ridge and Crawley's hill, Spring t.,	333
Little Germany ore banks,	98
Little Horseshoe trap dyke, Penn t.; Rye t.,	297; 317
Little Illinois valley, Toboyné t.; section (290'.)	351, 358
Little Juniata described, 25, 177; valley, 29; gap through Mahony ridge, 200; gap through Dick's hill, (see Montebello narrows,)	202, 203
Little mountain, VIII c 2, 16, 67; high, rough ridge in Spring t., 344; car- ries Hamilton fossil ore, in Rye t.,	100, 157, 315
Little Round Top mountain,	8
Liverpool P. O.,	3
Liverpool township described; rolling; chiefly Barger's Run valley; east end of Wild Cat valley,	241, 245
Liverpool gap, fine scenery,	241, 245
Lock levels on canal,	20
Locking of the mountains, Jackson t., an anticlinal spur splitting east end of Horse valley, 230; in Madison t.,	253
Long's (Darius) ore banks, VIII b 1, 3 m. W. of Bloomfield, Centre t.,	97 194, 209
Longacre's land, Oliver t.,	281
Loop on Sherman's creek, Wheatfield t.,	394
Losh's run, follows the fault,	85, 87, 202, 272, 285
" " station, P. R. R., West Duncannon turnpike,	300
" " mouth exposes VIII d with its fossils,	391
Lower Helderberg (Lewistown) limestone; see VI a,	58
" " fossils, 600' below bottom of VI, in V b, var. Sh.,	373
Loy's (Capt. And.) tract, VIII c 1,	327
Loysville, (Andesville,) Tyrone t.,	5, 231, 373
McAfee's fulling-mill, Spring t.,	343
McCabe's run, 24; synclinal valley,	29
" " Tyrone t.,	369
McClure's gap in Blue mtn., Tyrone t.,	370
McCormick's, VIII c 2, fossil ore,	100, 382
McCormick's sandstone quarry, Girty's notch,	151
McKee, (George,)	207
Madison township described; large; great valley between high mount- ains; divided by Chestnut ridge, with Sherman's creek gaps,	247
Magnesian limestone wanting to V b,	52, 180
Mahantongo,	395
Mahony ridge crest, VIII c 2, 15, 67; south slope, VIII f, 70; Hamilton fossil ore banks, 98, 100; in Centre t. described, 171, 200; in Miller t.,	271
Mannsville, Centre t.,	5, 15, 26
Manorsville Hamilton fossil ore, (VIII c 2,)	100

	Page.
Mansfield red banks of Potter and Tioga counties indicated in Saville t. by <i>Grammysia elliptica</i> ,	328
Marcellus formation—See VIII b.	
Maria furnace,	219
Markelsville, Juniata t.,	4
Map of Susquehanna river, old,	395
Marl, white,	208
Marls of the Onondaga group (V b),	54
Marysville, in Rye t.,	4
Mauch Chunk red shale, (see XI,)	79
Meck, (George,)	202
Medina sandstone; (see IV b c,)	43
Michael's ridge, (Slaughterbeck hill,) in Greenwood t., IV,	215
Middle ridge, 17; poor Chemung land,	71
“ “ western part, Kingsmill SS.,	74
“ “ at Newport, VIII d e f, Howe t.,	221
“ “ gentle slopes, cultivated to the top,	235
“ “ upper hard beds of VIII f, broad, round ends in the Newport bluffs, Juniata t.,	237
“ “ lower beds of IX, (or VIII-IX,) except at E. end,	238
“ “ escarpment made by Kingsmill SS.; débris,	239
“ “ VIII f, 274; overlooks Newport, 281; Saville t.,	328
Middle Bucks Valley ridge, VIII f, Buffalo t.,	17, 147
“ “ “ in Howe t., VIII-IX, and IX,	225
Mikqua Indians,	395
Milford, Juniata t.,	4
Miller township described; has four ridges and no stream of importance; mostly covered with timber,	265
Millerstown, Greenwood t.,	3, 361
“ ore beds, (Danville,) V a 3,	93, 323
Mining methods,	49
Mines of Marcellus, (iron ore,)	97, 98
Montebello, in Wheatfield,	4
Montebello narrows of the Little Juniata, through Dick's ridge, VIII c 2, Centre t., 14, 67, 202, 203; in Miller t.,	269, 271
“ “ shows fault,	86
“ “ section of rocks,	87
Montebello furnace in ruins,	387
“ “ bluffs of VIII f,	72
Montebello sandstone (Hamilton SS.) 500' to 800' thick, makes great rough ridges,	66, 67
Montebello (Hamilton) fossil ore, VIII c 3 a 2',	69
Monterey tannery, Toboyne t.,	5, 351
Montgomery ferry, Buffalo t.,	3, 147, 295
Montour run joins Sherman's cr. at Landisburg, Spring t., 24, 333; at L. Germany fault, 90; in Tyrone t.,	369
Moore, (R.,)	201
Mt. Pisgah, bold knob of VIII c 2, Spring t.,	344
Mt. Pleasant, Jackson t.,	5
Mt. Patrick, Buffalo t.,	3, 147
Mountains of IV described, 7; Toboyne t.,	354

	Page.
Mountain of X described,	10
Muddy run, in Tyrone t.,	367, 368
Murray (Laurel, Patterson) run,	230, 253
Mush (B. G.) & Co. ore,	96
Narrows, (see Gaps,) in VIII c 2, Center t.,	169, 198
Neilson's ore diggings, VIII b 1, Center t.,	194
New Bloomfield, Center t.,	4
New Buffalo, Watts t.,	3
New Germantown, Toboynne t.,	5, 349, 351
Newport, Oliver t.,	4, 239
Newport bluffs, VIII f,	72, 237, 274
Newport VIII c 2 fossil ore,	100
Newport furnace,	278
Newport limestone, local beds, high in VIII f,	224
Newport narrows, explained; (see Erosion,)	198
Newport section of VIII f (563'),	225
Niagara formation, wanting; (see V a b,)	52, 374
Nonconformity of VIII on V,	304, 305
North mountain; (see Blue mountain,)	8
North Furnace ridge, VII, Spring t.,	338
Northern Central railroad levels,	19
Northern synclinal trough described,	31
Oak Grove, Spring t.,	5, 101
" furnace, Rye t.; limestone point,	309; 374
" " high knob of VII, Spring t.,	339, 374
" " ore diggings, VIII b 1, Spring t.,	340, 375
Ochre beds, VII, Carroll t.,	101, 161
Ohio wharf road shows fault,	85
Old map of Susquehanna river,	395
Old road to Carlisle shows fault,	85
Oliver township described; all hilly, mostly wooded, second growth charcoal; Limestone ridge, Buffalo hill, Middle ridge,	277
Oneida conglomerate; (see IV a,)	43
Onondaga formation—See V b.	
Ore banks of old Juniata furnace, Center t.,	184
Ore banks—See Iron ore.	
Ore bed, fossil; (see V a,)	45
Ore ridge, Tuscarora t.; (see Iron SS.; Ore SS., V a 5,)	362
Ore sandrock described; (see V a 5,)	49, 94
" " chiefly instrumental in making the Blue mountain terrace in Tyrone t.,	370
Oriskany sandstone; (see VII,)	62
Orton, (Dr. E.,) of Ohio,	65, 341
Outlaw's cave; (see Girty,)	151
Overthrown; (see dips,)	181, 285, 310
Palæozoic formations.	36, 37
Palæozoic river, possible source of VIII c 2,	310
Passage beds of V b,	51
" " VIII e to VIII f in Centre t.,	207
Patterson, in Juniata county,	257, 259
Patterson's (Laurel, Murray) run, Madison t.,	253

	Page.
Patterson's, in Toboyne t., heads in Bear ponds,	349
Paving flag quarry,	326
Pebbles of rounded greenish shale in VIII-IX,	392
Penn township described,	283
Pennsylvania R.R. levels,	23
Perry county fault, 18 miles long; (see Fault,)	87, 159
" " in Miller t., 266; cuts VII, 2 m. N. of Bridgeport, Spring t., 338;	
S. W. end in Spring t., described,	345
Perry furnace, 14, 85; VIII c 3, ore,	100, 207
" " valley,	83
Peters' mountain, Penn t.,	9, 285
Peters' (M.) house in Watts t.,	385
Peterman's (G) VIII c 2 ore bed, 2' + Miller t.,	205, 272
Pfoutz's valley, anticlinal, Greenwood t.,	4, 15, 29
" " not so well isolated on the Susquehanna,	243
Phosphatic nodules,	291
Picturesque gorge of Buffalo creek through Bilman ridge, Savage t.,	321
Pilot Knob, Tyrone t., described,	1, 370
Pine hill, top sandstones of IX, Carroll t.,	78, 165, 395
Pine woods, second growth, on VIII f.,	71, 175
Pine Grove, Miller t.,	267
" " church, Centre t.,	192
" " church, Spring t.,	338
" " school-house, Centre t., VIII c 2 ore,	204
" " school-house, Miller t.,	204
" " narrows, Miller t.,	269
Pipe ore; (see iron ore, VIII b 1,)	97, 193, 194
Pisgah hill, VIII c 2, picturesque,	16, 67, 162
" " ore banks, VIII c 2,	98, 100
Plants now growing in Perry county, Chap. VI,	113
" " " in narrows of Centre t.,	169
Plant-rags in VIII f.,	393
Plications; (see Folds,)	33, 185
" conceal real thickness of formations,	71
" close in VI, Centre t.,	181
Pocono sandstone described; (see X,)	78
Polecat road shows fault,	85
Polecat valley, Rye t., eroded from V b; Spring t.,	157, 160, 303; 336
Poplar Hill cemetery, Centre t.,	188
Population of Perry county,	2
Portage formation; (see VIII e,)	69
Portage-Chemung passage beds and ore,	101
Portage fossils, near old mill, Drumgold's tannery, Carroll t.,	184
Portage shales, show fossils only near S. Brown's, Centre t.,	207
Power, (J.,)	189
Pulpit rocks of VII, near Bloomfield,	63; 209
Pumping by screw and steam engine,	194
Quaker hill, Bridgeport SS. V b, Spring t.,	336
Quarry of V. Ore SS., Waggoner's mill, Jackson t.,	232
" of V b limestone beds in variegated shale, near Loysville, Tyrone t., 373	
" of limestone in Half Falls mtn., Watts t.,	379

	Page.
Quarry of VI limestone, 86, 184; in Jackson t. north of Blain, 233; numerous in Liverpool t., 242; west of Centre in Madison t.,	259
“ of VIII b limestone, (D. Rice's),	262
“ of VIII b 2, Girty's notch,	151
“ of flagstone, (Shope's), Saville t.,	326
“ of IX red flags, good, Liverpool t.,	244
Quartz geodes in V b yellow shale,	374
Quatoochatoon, on old map,	395
Quick-lime, how it acts on land,	104
Raccoon ridge, VIII c 2,	15, 67
“ “ north slope, VIII c 1, Poorland, Saville t.,	326
Raccoon run described,	26
“ “ creek gap in Tuscarora t.,	365
“ “ valley, Liberty valley, Madison t.,	29, 249
“ “ in Saville t., fertile, V b,	324
“ “ in Tuscarora t., vertical beds of V b,	361, 363
Railway levels,	19
Rainbow rocks, near Beavertown, Ore SS. V a,	50
Ramer's house, south of Newport, Oliver t.,	280, 281
Rapids in Juniata made by VII, Buffalo t.,	150
“ “ made by VIII c 2, Miller t.,	270
“ in Susquehanna, Girty's notch, VIII c 2,	151
Rathvon's (C.) farm, fossil ore, VIII c 3,	100, 390, 391
Rattlesnake hill, notch in VIII c 2, Carroll t.,	161, 163, 390
Red shale (Bloomsburg), see V b,	45
Red and gray shale alternations V b, Enslow's Mill section, (801'),	233
Red and green shale alternations V b, Cissna's Run section (283')	257
Red and green shale alternations V b, Centre section, Madison t.,	258
Red shale in VIII f, Shermansdale section,	166, 167
Red passage beds of VIII-IX,	72
Red and green shale alternations of VIII-IX in Kingsmill section, Penn t.,	289
Red hematite seams in IX,	162
Reed (Mr.), Kingsmill, Penn t.,	290
Reeder's ore banks, (VIII b 1), N. E. of Bloomfield,	97, 188
“ “ near Juniata furnace,	195
“ “ trial of VIII c 2 fossil ore, Fulling mill, Centre t.,	204
Reef of VII across Juniata river,	150
Reepson's ore banks (VIII b 1), Spring t.,	341
Reutter's (Dr.) house, Watts t.,	385
Rheinsmith's limestone quarries (VI), Jackson t.,	234
Rhinehart's brick house near Delville,	166
Rice's (D.) quarry section, VIII b, Madison t.,	262
Rice (O.), Miller t.,	184, 189, 201, 268
Rice (Messrs.) ledge of VIII b 3,	340
Rice (Mr.), VIII b 5, whole thickness seen (80'),	342
Richland run, Perry furnace,	14, 157
Ridge (The), IX,	78
Ridges of VII in Miller t.,	267, 268
Ridge of VIII c 1 imitates VIII c 2, Savage t.,	326
Ridge road to Carlisle shows fault,	83
Ridge road from Newport west, all farms,	235

	Page.
Rising mountain, Toboyne t.,	8,349,355
River erosion, (See Erosion, Juniata, &c.,)	39
Rivers of Perry county described,	19
Roads on VIII b 5 outcrop very good,	65
Road to Montebello narrows shows fault,	85
Road over Bower mountain in Jackson t.,	229
Road along top of Middle ridge, VIII f, very good,	238
“ “ shows remarkably beautiful views, Juniata t.,	238
Road from Sandy hill to Roseburg, fine scenery,	321
Road metal, the best comes from quarry in VIII b 5, Spring t.,	341
Rock hill, VIII c 2, 16,67; Carroll t.=Dick's hill in Wheatfield t., and Pisgah hill west of Sherman's creek,	157,162
Rolls in the rocks due to side pressure,	40
Rope ferry, Oliver t.,	239,282
Roseburg, in Saville t.,	5,17,319
Round Top mtn., Toboyne t.,	8,355
Round Top, anticlinal knob, W. end of Dick's hill, Wheatland t.,	390
Roundsley's (Mr.) section of V a, Millerstown,	217,362
Rubbly upper beds of VI, exposed in quarries,	242
Rungold's tannery, near Gibson's rock, Carroll t.,	159
Run gap, ravine, Tuscarora mtn., Saville t.,	321
“ “ only exposure of IV a in the whole range,	322
Rye township described; Polecat valley, &c.,	303
Salina formation; see Onondaga, V b,	52
Sanderson, (Mr.,)	211
Sand from VII not sharp, but well rounded,	186
“ for building purposes from VII, N. Bloomfield,	208
Sand banks in the Palæozoic sea, Onondaga age, Bridgeport SS.,	57
“ “ of Oriskany age,	63
Sandstone, why green,	77,78
“ quarry at Girty's Notch,	151
“ ridges parallel, 800' apart, zigzags of VI, VII,	181
Sand-rock of V a; see ore-sand rock,	49
Sand-vein ore beds, V a; see Iron ore, V a,	45,49,51,95,217,335,363
“ “ on top of ore SS. displayed in Tyrone t., especially at Egolf's in Kennedy valley,	371
Sandy hill, Madison t., VIII c 2,	5,15,67,247
“ synclinal shows VIII overlooking Blain, Jackson t.,	234
“ synclinal of VIII c 2, Saville t.,	251
“ and Roseburg road, through fine gorge,	321
“ sulphur spring, VIII b, Saville t.,	325
Sandy hollow, Carroll t., Spring t.,	163,338
Saville township described; large; Buffalo mountain trough; curved out- crops, &c.,	319
Scenery fine down Bailey's run, Miller t.,	270
Scenery fine from top of ridges of VII, Spring t.,	333
Scenery fine in Toboyne t.,	357
Sea-level changes,	37
Second mountain,	9
Section of V b, Waggoner's mill, Madison t.,	256
“ of V b, Cissna's run, Madison t.,	256,257

	Page.
Section of V <i>b</i> , Centre, Madison t.,	257, 258
“ of V <i>b</i> , variegated shale, (327',) Landisburg,	372
“ of flint beds, Tuscarora t.,	364
“ of V <i>a</i> , Little Illinois valley, Toboyne t.,	358
“ of VI <i>b</i> , Clark's mill, Centre t., typical,	182
“ of VI, Garber's quarry, Spring t.,	337
“ of VIII <i>b</i> 1, Barnett's ore bank, N. Bloomfield,	193
“ of VIII <i>b</i> , Tudor's, Madison t.,	261
“ of VIII bottom, west of Centre mills,	262
“ of VIII <i>c</i> 2, Centre t.,	203
“ of VIII <i>f</i> , (563',) Newport beds, Howe t.,	225
“ of VIII-IX and IX, Barger's run, Liverpool t.,	244
“ of coal bed, Buffalo t.,	153, 154
Sediment in river water,	39
Seidel, (A.,) VIII <i>c</i> 2, fossil-ore tunnel, Rye t.,	95, 101, 314
Sequosockoo,	395
Schaeffer's valley in Jackson t.,	229
“ “ V <i>b</i> shales, narrow, wooded, secluded, Madison t.,	249
Shallow water, pebble bed, VIII <i>f</i> , Wheatfield t.,	393
Sharp mountain,	9
Sherman's creek and valley,	17, 24, 25, 27, 29, 157, 253, 367
Shermansdale, in Carroll t.,	5, 159
“ mill, Kingsmill SS. VIII-IX, 74; section,	166
Shope's flagstone quarry VIII <i>c</i> 1, 1 m. fr. Bixler's mill, Savage t.,	326
Shrubs of Perry county catalogued, Ch. VI,	113
Shull, (C.) quarry in VI <i>b</i> , Madison t.,	260
Side thrust of the formations amounts to 40 %,	41
Silicified corals of VI; see Fossils,	160, 183
Sink-holes numerous in fields of VIII <i>c</i> 2 ridges,	198
Slaughterbeck hill, (Michael's ridge,) Greenwood t. (IV),	215
“ “ anticlinal, natural fortress, visible from all sides,	216
Slickensides,	41
Slope of Perry county eastward; Sherman's creek,	25
Smiley, (C. H.,) of New Bloomfield,	395
Smith's (H.) ochre digging, VII,	101
“ VI quarry and red ochre banks, Carroll t.,	161
“ 3" coal bed in VIII <i>b</i> 5, near New Germany,	342
“ farm house, Wheatfield t.,	392
Soils requiring lime,	103
“ of top of hill slopes plowed away down hill,	175
“ of Pfoutz's valley good,	213
“ of northern hill land of Juniata t. very poor,	237
“ of northern Madison t. partly limestone and strong, but rather cold and hard to work; of southern, warm, red,	247
“ of Liberty valley, Madison t., warm and fertile,	249
“ of vale of New Bloomfield, warm and rich,	171
“ of Raccoon valley, V <i>b</i> , Savage t., fertile,	324
“ of V <i>b</i> , warm and fertile, undulating, Spring t.,	54, 336
“ of V <i>b</i> red shale, up Long valley, very fertile,	372
“ of VII in Madison t., yellow; no ridges of VII,	260
“ of VIII <i>b</i> 5, the poorest in the county, but makes the best roads,	65

	Page.
Soils of VIII <i>c 1</i> , valleys, white, poor, lean soil,	66,197,326,343,389
“ of VIII <i>d e f</i> meager in Watts t., steep slopes,	384
“ of VIII <i>f</i> very poor; “yellow slate soil,”	71,365; 392
“ “ “ bet. Mahony ridge and Dick’s hill, cultivated,	173
“ “ “ rolling and more productive than the lighter land of North Greenwood t.,	220
“ “ “ Middle ridge, cultivated, but so poor that it is reverting to wood land,	238
“ of IX better than of VIII <i>f</i> ,	215
“ of IX good in Liverpool t.,	244
“ of IX fertile rolling land,	293,316
“ of IX good rolling surface, S. and S. E. of Watts t.,	384
South furnace ridge at the fault,	86
South furnace hill, VIII <i>c 2</i> , cut off by fault,	344
Southern great synclinal trough,	31
Sparry limestone, at bottom of VI; see VI <i>a</i> ,	58
Speace, (J.,)	166
Spring township described; Sherman’s creek; Blue mtn.; Waggoner’s gap; Mt. Pisgah; Little mtn., &c.,	331
Spring of sulphur water, (Kepner’s,) Madison t.,	262
Springs, two at Falling Springs, copious,	339
Spring, large, on mtn. bet. N. Germantown and Concord,	349
Stalactites in caverns of VI, Saville t.,	325
Stalagmite floor, 1 foot thick, in “ “	325
Sterrett’s gap, topography,	14,159,309,311
Stinson, (J. M.,) chemist,	391
Stony creek,	101
Structure of Perry county,	31
Subsidence and elevation of earth crust,	37,306
Subsidence after VIII <i>b 5</i> in Rye t.,	309
Sugar run, Tuscarora t.,	361
Sulphury limestone, VI <i>a</i> ,	180
Sulphur spring, VIII <i>b 5</i> , ? Kepner’s, Madison t.,	262
“ “ VIII <i>b</i> , near Sandy hill, Saville t.,	325
“ springs at contact of III <i>a</i> and III <i>b</i> , Horse valley,	353
Surface shortened by plication 40%,	41
Surgent formation=Onondaga and Clinton, V,	51
Susquehanna river described,	19
“ gap at Liverpool, fine,	241
“ bridge section of upper shales of V <i>b</i> , (400’) complete, Rye t.,	313
“ locally called Big river, Watts t.,	382
“ old map,	395
Synclinals of Perry county described,	31
Synclinals of VII filled with iron ore,	268
Table of formations,	36
Temperature of Falling Springs, 55°,	348
“ of three warm springs, 60°, 61°, 65°,	348
Tannery at Centre, Madison t.; (see Rungold,)	258
Tapeworm road, beautiful scenery, Furnace hills, Centre t.,	202
Terrace of V ore series along Blue mtn.,	312
“ of Ore SS. along Blue mountain, Tyrone t.,	370

	Page.
Terrace of Bridgeport SS. 12' thick in Kennedy and Green valleys,	373
Thickness of formations, table,	36
“ of V <i>a</i> , 939',	46
“ of Scalent shales wrongly given by H. D. R. as 100' when it is really 700',	55
“ of VIII <i>d</i> , <i>e</i> , <i>f</i> hard to get on account of fold,	71
“ of VIII <i>d</i> , <i>e</i> , <i>f</i> reduced to one half in 6 miles east of Newport, Watts t.,	383
“ of rocks which the fault swallows,	88
“ “ “ by Little Germany fault,	90
“ of VIII <i>f</i> , 2700' to 2800' in Carroll t.,	164
“ of VIII-IX and IX on Barger's run 6000' to 7000' and does not yet reach top of IX,	244
“ of IX hard to measure on account of small rolls, Wheatfield t.,	395
Three Square Hollow, deep ravine, Cumberland co.,	231, 357
Thudium's tract, narrow valley between Blue and Little mtns., Spring t.,	331
Toboyne township described; largest in county; great mtn. zigzags; heads of Sherman's cr., Bear ponds, &c.,	349
Toomey, (M.,) Centre t., VIII <i>c</i> 2 ore crop,	68, 204, 206
Topography of Chemung hills (VIII <i>f</i>),	72
Town spring of New Bloomfield,	177
Towns of Perry county enumerated,	3
Townships enumerated,	2, 3
“ affected by structure; Bilman ridge, gaps, &c.,	321
“ of VIII <i>c</i> confused by sandy nature of VIII <i>c</i> 1 middle beds in Saville t.,	326
Transition (Passage beds) VI to VII, Buffalo t.,	149
“ of black shales (VIII <i>b</i> 5) into gray shales (VIII <i>c</i> 1,) without any break of sequence,	342
Trap dykes of the Cove, Penn t.,	79, 293
Trap dyke across Cumberland county,	294
“ “ No. 1, enlarges suddenly,	296
“ “ No. 2, only 6' to 8'?	297
“ “ No. 3, 6' to 8' in White's well, pitches 45°,	298
“ “ No. 4, S. 20° W. trace by red soil and blocks,	299
Trap dykes do not seem to reach mtn. crests,	299
“ north of the Cove,	299
Trap dyke changes course at pit W. of R. R. station,	300
“ not seen in river bed,	300
“ 50' thick in R. R. cut, east bank,	300
Trap dykes in Rye t.,	316
Trap mistaken for magnetic iron ore,	301
Trap dyke (East Duncannon) across Watts t.,	384
Trees of Perry county catalogued,	113, 175
“ in Dorrans gap,	199
Tressler's red and green brick clay, Juniata t.,	237
Troughs described; (see Synclinals,)	31
Troutman (Isaac) mined VIII <i>b</i> 1 ore,	219
Tudor's (S. M.,) section of VIII <i>b</i> , Centre mtns.,	261
Tunnel to Reader's VIII <i>b</i> 1 ore bed, Centre t.,	188
“ for coal in Cove mtn., 200',	292
“ “ “ in VIII <i>b</i> 5, (!) Spring t.,	342

	Page.
Tunnel for coal in Foosse's,	343
Turkey ridge, VIII c 2,	15, 67
Tuscarora township described; long, narrow, very mountainous; four ridges; Tuscarora mtn., Ore ridge, Raccoon ridge, Horning ridge; all cut by Juniata,	361
Tuscarora creek at Waterford narrows, Toboyne t.,	354
Tuscarora mountain, East and West,	7, 8
" " East; anticlinal IV, rough, steep, wooded,	249
" " slope in Madison t. rocky; hides ore crop,	255
" " solid wall between Saville t. and Juniata county,	321
" " split lengthwise by head waters of Run Gap run,	321
Tyrone township described,	367
Upper Helderberg, Corniferous limestone absent,	64
Utica slate; (see III a,)	43
Vale of Bloomfield,	231
Valley, a term of two meanings,	27
Valleys excavated by rivers,	39
" of Tyrone t. long, narrow, secluded, fertile,	372
Variegated shales (V b) over Bloomsburg red shale, 700',	54
Vermicular limestone of New York, V b,	52
View from Duncannon hill, fine,	78
Villages enumerated,	3
Volcanic rocks; (see Trap-dykes,)	79
Waggoner's Mill, Toboyne t.,	373
Waggoner's Mill section V b, 615',	53, 57, 256
" " Ore sandrock stone quarry, Jackson t.,	231
Walnut Grove school-house gap, Juniata t.,	239
Warm spring in small synclinal, Spring t.,	339
" " Bower's, on Sherman's creek,	347
Wash ore (VIII b 1,)	97
Waterford narrows, at junction of Horse Valley run and Tuscarora creek, Toboyne t.,	354
Water lime formation; (see VI a,)	60
Water-works by Archimedes' screw,	193
Watts township described; mountains; slopes to the river; thinly settled,	377
West Duncannon trap dyke,	298, 300
West Round Top, Toboyne t.,	356
West Tuscarora mountain,	230, 354
Wheatfield township described; long, narrow, mostly poor land of VIII f,	387
White, (I. C.,)	75
White, (J. M.,) well and trap dyke, Penn t.,	298
White flint shale; (see VI d,)	59, 62
White chert debris in Buffalo cr. gap,	199, 200
Wildcat ridge, VIII c 2,	15, 67
Wildcat run,	17, 26
Wildcat valley in Greenwood t.,	4, 29, 215
" " shows Kingsmill SS. VIII-IX,	74
Wilderness of Toboyne t.,	356
Woods cover Buffalo mtn.,	245
Work done by rivers; (see Erosion,)	39
Yellow flint shale; (see VI c,)	59

	Page.
Ziggags of V, VI, and VII,	13
“ at Dick’s Hill bridge, Wheatfield t.,	390
<i>Formation No. III, Trenton limestone.</i>	
“ Horse valley, Toboyne t., nowhere visible,	352
<i>Formation No. III a, Utica slate.</i>	
“ in Horse valley, Toboyne t.,	43, 352
“ sulphur springs at contact of III a, b,	
<i>Formation No. III b, Hudson River (Lorraine) slate.</i>	
“ in Horse valley, Toboyne t.,	353
<i>Formation No. IV a, Oneida conglomerate.</i>	
“ exposed in only one place, in the ravine of Run gap, Saville t.,	322
“ not gapped in Tyrone t.,	370
<i>Formation No. IV b, Lower, red, Medina sandstone.</i>	
“ well displayed in the counties north-west of Perry, but not distinguishable from IV c in this region,	
<i>Formation IV c, upper, white Medina sandstone.</i>	
“ described in general, IV a b c,	43
“ thin, runs outside Carroll t. line in Cumberland co.,	159
“ in Greenwood t. makes Slaughterbeck hill,	216
“ in Madison t. has five outcrops,	253
“ in Rye t. only about 100' thick, and makes the south crest of Blue mountain, mostly within the limits of Cumberland county,	310
“ at the Susquehanna River gap seen to be overthrown so as to dip southward,	310
“ in Spring t. makes a crest in Cumberland co.,	333
“ in Toboyne t. makes eight mountains,	354
<i>Formation No. V a, Clinton shales and fossil ore.</i>	
“ described and compared with New York,	44, 45, 46
“ two beds on Burn’s farm, Blue mtn,	159
“ concealed along rocky, woody slope of Conococheague mountain, in Jackson t.,	231
“ well exposed on the Chestnut ridge arch,	231
“ best exposed in the two gaps of Sherman’s creek through Chestnut ridge,	232
“ detailed in Bistline Mill section, Madison t.,	255
“ hard to trace in Toboyne t.,	357
“ becomes calcareous in its upper part,	358
“ two outcrop belts in Tyrone t.,	370
<i>Group V a 1, Clinton lower shales.</i>	
“ described generally,	47
“ exposed near Sterrett’s gap,	159
“ well exposed in Madison t. on mountain road from Buffalo mill to Sandy hill, on the Conococheague anticlinal,	254
“ 500' thick, makes a broad cultivated crest to Blue mountain, in Rye t., and Spring t. no good exposures,	311, 335
“ concealed by rocks on mountain in Saville t.,	323
<i>Group of V a 2, Clinton iron ss. and black ore.</i>	
“ described generally, variable,	48, 50, 93, 94
“ makes a ring wall around Slaughterbeck hill, Greenwood t.,	216
“ makes Chestnut hills in Jackson t.,	230

Group of V a 2, Clinton iron SS. and black ore.

- " thickens rapidly in Madison t. along Conococheague mountain; makes bold terrace marked with fragments, 254
- " makes north crest of Blue mountain, Rye t., 311
- " 10' to 20' thick, in thin layers, fragments, 312
- " thin along Tuscarora mountain in Saville t.; few fragments noticeable in the débris of Run gap; thickens westward and covers the surface with slabs, 323
- " very thick in Spring t.; makes northern crest of Blue mountain rivaling in height the south crest (IV c); its thin, flat plates spoil the red shale slope of the mountain, and encumber the runs, 355
- " makes one ridge with the ore SS (V a 5) in Tuscarora t., called Ore ridge, 362

Group of V a 3, Clinton upper shales.

- " described generally, 48, 49
- " in Saville t., along Conococheague anticlinal, shows gray soil, . . 323

Group of V a 4, Clinton Ore SS.

- " described generally, 49
- " never more than 20' thick, 50
- " makes a fine bold outcrop, Rainbow rocks, &c., 50
- " thin in Chestnut ridge, Madison t., gapped, 247
- " very fossiliferous in Madison t., 254
- " resembles IV c in Saville t., 324
- " easily distinguished in Madison t., 324
- " finest exposure in Little Minor's valley, 358
- " conspicuous and often fossiliferous in Buck hills south of German-town, Toboyne t., 358

Group of V a 5, Danville ore beds.

- " a conspicuous plane of division between Clinton V a and Onondaga V b, 45, 46
- " described, 49, 95
- " limestone, 51
- " not seen in Rye t.; no well-marked ridge, but a terrace, 312
- " in Greenwood t.: only worked at Millerstown, east side of the river, 217
- " in Saville t., no signs of the ore beds, 323
- " equivalent of Danville fossil ore beds, 323
- " runs through Saville t., but not opened, 324
- " not seen in Spring t., 335
- " indicated, but looks poor in Toboyne t., 358
- " *Sand Vein ore bed* the only one worked at Millerstown, 363
- " limestone quarried in Little Minor's valley, Toboyne t., . . . 358

Formation—Niagara.

- " wanting to Perry county. It should come in on top of the Sand Vein ore bed, but no Niagara fossils have been found, 52

Formation No. V b Onondaga shale.

- " described generally, 51, 52
- " lower limit, the top of the Sand-vein ore-bed, 46
- " underlies most of Jackson t., 232
- " 801' shown in Enslow's Mill section, 233
- " nameless valley bet. Chestnut ridge and Bower mtn., in Madison t., 251
- " upper part of Bistline's mill section, 255

Formation No. V b, Onondaga shale.

" sub-divided in Madison t.,	256
" 1400' thick in Rye t.; lower (red) layers not well exposed; 400' section of upper beds complete at the Susq. river bridge,	312, 313
" makes Raccoon valley, Saville t., fertile,	324
" non-fossiliferous,	324
" fossiliferous at Buffalo mill, Saville t.,	324
" crop a mile wide (Elliottsburg valley) bet. Limestone and Mahony ridges, Spring t.,	335
" makes broad flat plain around Bridgeport,	336
" makes (Polecat) valley bet. Blue mtn. and Pisgah hill,	336
" vertical along Raccoon valley, Tuscarora t.,	363

Group V b 1, Bloomsburg red shale of Report G⁷.

" no Clinton fossil form as yet found in it,	51
" fossiliferous only in a few places,	51
" 700' thick; spotted green,	53
" 830' thick in Madison t.,	255
" good section got west of Waggoner's mill,	256
" fills all the synclinal valleys of Toboyne t.,	359
" 700' thickness of red shale well exposed south of Landisburg,	371
" saddles all the anticlinals of Tyrone t.,	373

Group V b 2, Bridgeport sandstone.

" described; Bistline's Mill section,	57
" 5' thick; under 200'; over 500' red shale,	58
" at Bistline's mill, and at other places in the county,	255
" curious bed of flinty sandstone, cropping out on Sherman's creek, south of Bridgeport on the Welsh mtn. anticlinal,	336
" makes Quaker hill, Spring t.,	336

Group V b 3, Onondaga variegated upper shale.

" 700' thick over Bloomsburg red shale,	54
" 200' to 250' (?) grey shale at foot of slope and in flat of valley, Centre t.,	179
" absent from the Susquehanna river bridge section in Rye t.,	313
" 700' to 800' thick in Tyrone t., measured from Bloomfield SS. down to solid Bloomsburg red shale,	372
" (327') in the Landisburg section,	372
" well exposed in Sheranan's cr., 1½ m. W. of Loysville,	373
" 800' of upper more calc. beds here seen,	373
" may be traced several miles along middle of Kennedy's and Shaeffer's valleys,	373
" gray shales, over top of Landisburg section and under VI; as usual, about 200 feet,	372

Group V b 4, Bloomfield sandstone.

" described; thin in Centre t.; makes ridges,	54, 177
" makes a low ridge along the middle of valley,	179
" noticed in Jackson t.; nineteenth mile-stone section,	233

Formation No. VI, Lower Helderberg.

" limestone ranges described,	12
" formation stops at Sterrett's gap,	14
" formation as a whole described,	58
" limestone bottom beds bituminous,	58

	Page.
<i>Formation No. VI, Lower Helderberg.</i>	
" 348' thick in section; characteristic fossils,	60
" faulted against VIII c; throw, 2300',	85
" much contorted at quarry in Buffalo t.,	149
" not extensively exposed in Buffalo t.,	149
" top of formation grows sandy upwards into VII,	149
" brought up against VIII c 3 by the Perry Co. fault, in Carroll t.,	159
" quarried largely at J. Bear's, Carroll t.,	160
" disappears eastward at Sterrett's gap, Carroll t.,	160
" makes a ridge from Sterrett's gap westward,	160
" at Smith's quarry, Carroll t.,	161
" VI a + b, 300' to 400' in Centre t.,	180
" folded so closely and so often as to make a wide belt,	186
" 600' in Greenwood t., not easily differentiated,	218
" heavy solid bituminous limestone mass,	218
" two synclinal troughs cross Jackson t.,	233
" 60' exposed at Hall's quarries in Jackson t.,	233
" two outcrops cross Liverpool t.; well exposed along both lines; many quarries; much lime made at head of Pfoutz's valley,	242
" upper rubbly beds, under fossiliferous beds and over solid beds in the Liverpool t. quarries,	242
" upper rubbly beds yield few fossils, except the ubiquitous <i>Leperditia</i> <i>alta</i> ,	242
" undulates broadly through northern-central part of Madison t.,	259
" wanting (as well as VII and VIII a b) in Rye t.,	304
" thins from Oak Grove furnace eastward to 0' before reaching Sterrett's gap in Rye t.,	309
" lower beds thin out first; higher beds persist further eastward; proof of nonconformity,	309
" outcrop in Saville t., straight past Ickesburg, and then zigzagged,	325
" broken and crushed, although nearly horizontal,	325
" caverns, large, with stalactites, &c., &c.,	325
" outcrop zigzags through Spring t.,	333
" limestone land in Spring t. abundant,	333
" forms high bold ridges, often capped with VII,	333
" spreads widely at Elliotsburg,	337
" makes Bell's hill,	337
" section at Garber's quarry, Spring t.,	337
" makes low ridge through Raccoon V., Tuscarora t.,	363
" synclinal points in Tyrone t.,	374
" small show in Watts t.,	378
" much disturbed and no fossils, Watts t.,	378
<i>Group VI a, Lewistown limestone.</i>	
" Bossardville limestone of Report G ⁶ ,	58
" 100' massive, quarried, general section,	60
" has a few fossils,	61
" yields all the lime made in Center t.,	179
" 60' to 70' thick, near N. Bloomfield, &c.,	179
" its fragments, beveled slabs, resonant, cover the plowed fields without impeding agriculture,	180
" has a few fossils in Center t.,	180

	Page.
<i>Group VI a, Lewistown limestone.</i>	
" sometimes crowded with <i>Leperditia alta</i> ,	180
" place of the Waterlime formation in N. Y.,	180
" dark when freshly broken; weathers whitish; shows lamination; often very bituminous, "sulphury;" Center t.,	180
" makes a hot, fat, strong lime,	180
" not dolomitic in Center t.,	180
" blue limestone quarry rock in Madison t.,	259
" 40' thick in Saville t.,	325
<i>Group of VI b, Clark's Mill lime shale.</i>	
" described in Centre t.,	57, 181
" 150' thick at Clark's mills,	60
" <i>Pentamerus</i> Lower limestone of New York,	61
" fossils enumerated,	61
" <i>Lewistown lime shales</i> of Report F,	181
" seldom quarried in Madison t.,	259
" quarried at Bixler's mills,	259
" <i>Meristella</i> beds, &c., fossils, not many here,	259
" exposed near Falling spring, Spring t.,	337
" <i>Stromatopora</i> bed well exposed,	337
" exposed in Gibson's old quarry, Spring t.,	337
<i>Group of VI c, Black Cherty limestone.</i>	
" 8' thick, as described,	60
" well exposed at Half Falls mountain, Buffalo t.,	149
" well exposed at Millerstown,	218
" outcrops in Miller t.,	266
<i>Group VI d, Yellow flint shales.</i>	
" 80' in general section,	59, 60
<i>Group VI e, White flint shales.</i>	
" 10' in two beds, Half Falls mtn., described,	59, 60
" crowded with fossil casts,	60
" make fine ridge in Liverpool t.,	242
" land surface covered with fragments,	242
" can be traced in Rye t., nearly to Sterrett's gap,	309
<i>Formation No. VII, Oriskany sandstone.</i>	
" possibly coeval with <i>Corniferous limestone</i> ,	63
" 25', never more; described,	62
" thin and sometimes absent in Pfoutz's valley,	62
" thickest in Sherman valley,	62
" often fossiliferous; casts only,	63
" very ferruginous in N. W. townships,	63
" no real iron ore bed,	63
" no glass sand,	63
" beautiful pulpit rocks, especially near Bloomfield,	63
" folded into VI, repeatedly,	63
" outcrops on Perry furnace road,	85
" faulted,	89
" very ferruginous N. E. of Blain; no ore,	101
" no sharply defined limit at base; because top of VI grows sandy up- wards,	149
" conglomerate of fine white pebbles, Buffalo t.,	150

	Page.
<i>Formation No. VII, Oriskany sandstone.</i>	
" rough low ridges, pulpit rocks, &c., Centre t.,	185
" 20' only, in the ridges of Centre t.,	185
" conspicuous for numerous parallel synclinal outcrops along Lime- stone ridge, Dick's hill, and Iron ridge,	184, 185
" usually a hard solid rock in Centre t.,	186
" sometimes crumbly, easily quarried for rough casting sand for build- ings,	186
" conglomerate of little, bean-shaped, white quartz pebbles, mixed with some of larger size in Centre t.,	186
" ridges disappear occasionally where the rock is locally crumbly,	187
" no ore deposit known in Perry county,	187
" supposed ore is only iron-stained sandstone fragments,	187
" tongues on the map in Centre t.,	188
" finest exposure in the county, cliff,	189, 190
" very thin near Millerstown, poor outcrop, no pulpit rocks, hardly a fragment to be found; probably thins to nothing eastward at east end of Greenwood t.,	218
" overlooks Blain, on Sandy hill, Jackson t.,	234
" absent from Liverpool t., probably,	241
" sand makes the fertility of Centre valley, Madison t.,	249
" much folded, zig-zag, much softer in Madison t. than in the center of the county,	260
" soil yellow; only way to trace VII; no ridges,	260
" undulated and compressed in Miller t.,	267
" double ridge where it crosses the Juniata,	267
" close behind old graveyard, 1st crop,	267
" passes Clouser's ore works, rough ridge, 2d crop,	268
" high synclinal ridge, 2 m. W. of Baileysburg, 3d crop,	268
" makes crest of Inoculate ridge,	268
" contains much iron ore; double synclinal, &c.,	268
" narrow synclinal ridge, past Clouser's, 4th crop,	269
" along N. foot of Dick's hill, Miller t., 5th crop,	269
" absent in Rye t., east of Sterrett's gap,	309
" zig-zag in Saville t.,	325
" greatly folded and zig-zaged in Spring t.,	338
" in ridges of Ellitsburg, past Pine Grove church, south of Blooms- burg,	338
" in North Furnace ridge, Spring t.,	338
" along north side of Sandy hollow and north bank of Sherman's creek, pass Falling and Warm springs to knob at Oak Grove furnace,	339
" hard, rough, ferruginous in Spring t.,	339
" furnishes the two springs at Falling spring,	339
" fairly well exposed opposite Millerstown,	364
" scarcely noticeable in Tyrone t.,	374
" on Landisburg hill, but not on Bell's hill,	374
" 20' thick along north line of Watts t., bold ridge; makes dam across Juniata; makes Half Falls,	379
<i>Formation VIII a, Upper Helderberg.</i>	
" apparently absent from Perry county,	64

Formation VIII a, Upper Helderberg.

" improperly recognized in the limestone under 500' greenish slates of
VIII b 2, 191

" no Corniferous fossils found in VIII b, 2, 3, Madison t., 260

Formation VIII b, Marcellus limestone and black slate.

" described, 64, 65

" only seen in few places in Centre t., 190

" well developed at M. Barnett's, 190

" where well developed, no iron ore, 191

" not well exposed in Greenwood t., 218

" Local sandstone, at bottom, at Montebello narrows, 269

" rich in brown hematite iron ore in Oliver t., 278

" whole formation absent in Rye t., E. of Sterrett's gap, 309

" sulphur spring near Sandy hill, Saville t., 325

Group of VIII b 1, Marcellus lower iron ore.

" 2' worthless; only ochre beds, 64

" see Iron ore over VII, 187, 188

Group of VIII b 2, Marcellus lime shales.

" 50', described, 64

" hard close-grained sandstone at the bottom, in one locality in the
county, at Montebello narrows, 269

Group of VIII b 3, Marcellus limestone.

" 50', described, 64

" won't slack, in Centre t., 190

" exposures abundant and complete, in Madison t., 260

" very interesting fossils; no corniferous forms, 261

" fragments numerous at N. end of Pine Grove narrows, Miller t., 269

" 50' hard beds; Gibson's mill, Spring t., 339

" well exposed, but elsewhere much covered up, 339

" fragments of trilobites (*Dalmanites*?) Gibson's mill, Spring t., 339

" not seen in Tuscarora t., 364

" sought for but not found at the Half Falls, although reported in Geol.

Pa., Vol. I, p. 138, 379

Group VIII b 4, Marcellus Upper iron ore.

" described; brown hematite ore, 64, 94

" in Center t., described, 191

" Lewistown ore bed, local name, 191

" normally 50' over top of VII, 191

" abundant when limestone is poorly developed, and *vice versa*, 193

" Barnett's mine, Bloomfield, 193

" Long's mine, Center t., double bed, 4' to 14' thick, parting of clay;

100 wash tons per month; price at Newport \$3 50, 194

" changes in the deep to blue carbonate ore, 194

" outcrop near Perry furnace; also N. of Bloomfield, 195

" 1' to 3', at Tralltwine's mine, Greenwood t., 219

" sent to Maria furnace, 219

" fine display on road in Madison t., 263

" fills fold in VII, Inoculate synclinal ridge, 268

" rich in Oliver t.—smelted at Newport, 278

" outcrop near Sandy hill, Saville t., less striking, 325

Group VIII b 4, Marcellus iron ore.

" outcrop zigzags over Spring t.; mines numerous,	340
" 50' over VII; inexhaustible quantities,	340
" abundant west of Perry furnace,	341
" diggings abandoned S. W. of Little Germany,	341
" not seen in Tuscarora t.,	364
" VIII b 4, 5, dug on high knoll opposite Oak Grove furnace, Tyrone t.,	375

Group VIII b 5, Marcellus black shales.

" 100' thick; described,	64
" passes up into VIII c 1, Ham. lower shale,	65
" ferruginous, pyritous, full of <i>Sporangites</i> ,	65
" described in Center t.,	195, 196
" with VIII c 1 makes a deep valley, Center t.,	196
" exposed best at Barnett's rocks, on Dorran's run, Juniata furnace ore banks, Center t.,	196
" seen occasionally on N. slope of Wildcat ridge, Greenwood t.,	219
" displayed bet. Bixler's mills and Sandy hill, Madison t.,	262
" Sulphur spring near Sandy hill, Saville t.,	325
" best displayed in Spring t., at quarry near Little Germany,	341
" makes excellent road metal,	341
" some lower solid beds calcareous,	341
" no fossils except minute <i>Sporangia</i> ,	341
" 80', whole thickness exposed at Rice's bet. school-house and saw-mill near N. Germany, Spring t.,	342
" gradual transition upward into rusty, ochreous, pink-gray shales of VIII c I Rice's,	342
" seen at low water in Juniata, Watts t.,	379

Formation VIII c, Hamilton shale and sandstone.

" 900', described,	66
------------------------------	----

Group VIII c 1, Hamilton lower shale.

" 400' to 500' soft shales; lean soil; valleys,	66
" in Centre t. described; exposures rare,	197
" wooded valley across Oliver t.,	279
" thins to 0' at Susquehanna river, in Rye t.,	313
" covers much of S. W. and central Saville t.,	326
" undulated westward; poor land,	326
" northern outcrop runs along N. slope of Raccoon ridge,	326
" middle beds become very sandy in Saville t., much resembling VIII c 2; differs, however, in being even, thin-bedded, hard, dark green flags,	326
" extensively outspread in Spring t.,	343
" fine outcrops at W. end of Mahanoy and Crawley hills,	343
" fine section on road from Little Germany to McAfee's mill,	343
" fine exposure along Little Germany fault valley,	343
" very barren of fossils; white meager soil,	343
" usually covered with forest, as in Tuscarora t.,	364
" makes a great show in Wheatfield t.; peculiar whitish soil,	389

Group VIII c 2, Hamilton (Montebello) sandstone.

" hill ranges described,	15
" 500' to 800', Montebello sandstone, high rough ridge,	66

	Page.
<i>Group VIII c 2, Hamilton (Montebello) sandstone.</i>	
" thinner in Pfoutz's valley,	67
" very thick at Marysville,	68
" high ranges in Centre t. mostly cultivated,	197
" sink-holes numerous along strong bold outcrop,	197
" 600' in gap of Centre t.,	201
" Middle beds well exposed in Crawley's ridge,	201
" soft middle member, in which streams zig-zag,	203
" section, Centre t.,	203
" in Wild Cat ridge; high, hard, and solid near Juniata river; grows soft and shaly, smoother ridge, eastward into Liverpool t.,	219, 220
" consequently, ridge low in Liverpool t., and Pfoutz's valley not so isolated as in Greenwood t.,	241
" scarcely enters Howe t.,	223
" makes Turkey and Wild Cat ridges in Liverpool t., but softer, shaly, less sandy, ridge slopes easy, and cultivated to their tops,	243
" four outcrops in Miller t.,	270, 271
" makes rapids in Juniata river, Buffalo Hill gap, Miller t.,	270
" Buffalo hills, in Oliver t., rugged; dip 75° N. N. W., flattens to 25° to 30°,	279
" source of the sand,	309, 310
" Little mountain, in Rye t., steep, rough, wooded; crest a pile of dis- jointed blocks,	313
" 800' complete section on Susquehanna river, where the formation is thickest,	313
" solid, hard middle beds, thinner shaly beds above and below, on Susq. river, Rye t.,	314
" Bilman ridge, Saville t.,	321
" Middle bed imitated by VIII c 1, locally in Saville t.,	326
" bold outcrop in Buffalo hills, Saville t.,	327
" folded; gapped by Buffalo creek; dip 30°+,	327
" Raccoon ridge, Saville t.,	327
" Mt. Pisgah, at synclinal angle, Spring t.,	344
" steep rough-wooded range across Tuscarora t.,	364
" makes converging ridges, rough country in northern part of Watts t.,	379
" doubled from 800' to 1800' by the Perry co. fault in Half Falls mtn.; universal dip 40° to 50°,	380
" crest of Dick's hill faulted up in Wheatfield t., dip 30° to 90° in short distance,	389
<i>Hamilton fossil ore, described,</i>	<i>99, 100</i>
" in Centre t., described,	204
" not mined in Oliver t.,	280
" 360' above base of VIII c 2,	314
" exposed at signal-box at Junction R. R., Rye t.,	314
" never opened in Spring t.,	345
" in Watts t., only opened at Girty's notch,	382
" in Wheatfield t., along south flank of Dick's hill,	390
" Iron ore on top of VIII c 2, poor ore,	204
<i>Group VIII c 3, Hamilton upper shale.</i>	
" 200' to 300', described,	66, 68

	Page.
<i>Group VIII c 3, Hamilton upper shale.</i>	
" fossils,	69
" at Girty's notch, Buffalo t.,	150
" in Centre t., described,	205
" three various exposures in Centre t.,	207
" a little near Old Tavern in Howe t.,	223
" four lines in Miller t.; on the 1st no good exposure; second near Peterman's ore works,	273
" crop 100 yds. S. of Ramer's; zigzags across Oliver t.,	280
" very calcareous; <i>Fenestella</i> abundant; road from Newport to New Bloomfield, Oliver t.,	280
" <i>Fenestella</i> shales, Oliver t.,	280
" zigzags; very fossiliferous and fossils good, especially <i>Spirifer granulifera</i> on road from Mannsville to Roseburg, Saville t.,	328
" at Girty's notch in Watts t.,	383
" runs along S. flank of Dick's hill, in Wheatfield t., but is seldom exposed, and is less fossiliferous than at Bloomfield,	390
" zigzags at west end of Dick's hill, along which it dips uniformly 30° S.S.E.,	390
" has a local 2' fossil ore bed in Wheatfield,	391
<i>Formation VIII d, Genesee slate.</i>	
" 200' feet described,	69
" erroneously stated at 1120 (!)	71
" concealed and nonfossiliferous in Centre t.,	207
" 200' barren shales, Oliver t.,	280
" well exposed at mouth of Losh's run, with fossils, Wheatfield t.,	391
<i>Formation VIII e, Portage shale.</i>	
" 200' described,	69, 70
" fossils recognized in Centre t. only at S. Brown's,	207
" VIII e f, passage beds well shown near S. Brown's,	207, 208
" <i>Cardiola</i> shales on two roads south of Newport, Oliver t.,	281
VIII d + e makes low ground between Baileysburg and Newport,	274
VIII d + e + f, 3300' in the northern townships,	71
" " makes peninsula N. Miller; river cuts three times across the whole,	274
" " 3800' above Newport; only 1100' in Rye t.,	315
" " overturned; not exposed on railroad along Susquehanna river,	315
" " thins eastward in Watts t. to one half (?) of what they are at Newport, six miles west,	383
" " broad belt across Watts t. much folded,	383
<i>Formation VIII f, Chemung.</i>	
" described; contorted; fossils,	70
" topography; upper limit not defined,	72
" 2700' or 2800', Carroll t.,	164
" plant beds and red shale,	166, 167
" cut off by great fault in Centre t.,	207
" fossiliferous in many places, but few exposures,	207
" makes half of Wild Cat valley, Greenwood t.,	220
<i>Newport limestone</i> , a mass of fossil casts; the water-bearing bed of the wells of Newport; exposed opposite the furnace at Newport; local to Howe and Oliver townships,	224

	Page.
<i>Newport limestone</i> , high up in VIII <i>f</i> , and not at its base as has been supposed,	224, 225
" <i>Newport limestone</i> crowded with <i>Strophomena demissa</i> , &c.,	224, 225
" <i>Newport limestone</i> , 3' thick,	225
" covers N. and S. Juniata t. in two broad belts,	237
" fossils not abundant; distorted along Middle ridge, Juniata t.,	238
" makes bluffs of Juniata between Baileysburg and Newport,	274
" hard layers of upper VIII <i>f</i> make rough wooded range of low hills at north foot of Dick's hill, Miller t.,	274
" over Newport,	281
" slope of Middle ridge, Saville t., exposed along road; few extensive fossiliferous outcrops; west end of Hominy ridge,	328
" upper beds unusually red and sandy in Saville t.,	328
" holds fossils not seen in them in the southern townships of the county, . .	328
" ridges high and ravined; poor soil in Tuscarora t.,	365
" makes broad belt across Wheatfield t.,	391
<i>Group VIII f-IX, passage beds.</i>	
" described,	72
" contains <i>Kingsmill shales</i> ,	77
" makes Middle Buck valley ridge in Howe t.,	225
" long and good section on Barger's run, Liverpool t.,	244
" exposed in railroad cuts, Oliver t.,	282
" 1557' in Linton's Hill section, Penn t.,	290
" section $\frac{1}{2}$ m. N. of Kingsmill, Wheatfield t.,	392
" no traces of fish bed near top of VIII <i>f</i> in Kingsmill section, Wheatfield t.,	392
<i>Kingsmill shales</i> described,	77
" full of <i>Beyrichia</i> ,	77
<i>Kingsmill sandstone</i> , 12' thick, makes curve into Saville t., outcrops in D. Long's woods,	329
" described,	73
" continuous at 500' above top of Chemung, showing transition of VIII to IX,	74, 75
" very fossiliferous exposures around Shermansdale, Carroll t.,	159
" in Carroll t.,	165
" Delville section, Carroll t.,	166
" white sandstone north of mill,	167
" not so bold in Greenwood as in Wheatfield,	220
" white; not so siliceous; clay tougher; fossils scarce,	220
" road on which alone fossils have been seen in Greenwood t.,	220
" makes northern escarpment of Middle ridge, Juniata t.,	289
" best seen, covering ground with fragments, west of Walnut Grove, Juniata t.,	289
" Stony ridge, left in woods Liverpool t.,	245
" exposed 2 m. N. of Liverpool, near Dry Saw-mill,	245
" in Penn t.,	287
" honeycombed with casts of <i>Schizodus rhombens</i> and other lamelli-branches, drifted dead shells,	291
" makes several stony ridges across Watts t.,	384

	Page.
<i>Formation No. IX, Catskill red sandstone.</i>	
" 6000' described,	72
" Delville ss., the assumed base of IX,	77
" " " why green,	77, 78
" upper beds described,	78
" iron ore, red hematite, near Oakgrove,	102
" top mass makes Pine hill, Carroll t.,	165
" Delville green sandstone, 20', at Judge Junkin's, near Delville, Carroll t.,	166
" nearly all cleared and cultivated except steep banks of Buffalo creek, Juniata t.,	238
" upper hard beds of Duncannon terrace are soft and make a low hill in Juniata t.,	239
" bottom beds hold yellow shales and thin square-fracture, fine-grained sandstone layers like Chemung or Barger's run, Liverpool t.,	244
" not well exposed on Susq. river, Liverpool t.,	244
" bottom edge line, crosses Liverpool t. a few hundred yards north of Liberty Hall, and runs to Susq. river near Dry Saw-mill,	244
" shales above the base of true Catskill seen only in one place in the county, between Kingsmill and Linton's hill, Penn t.,	257
" Delville green sandstone, with coaly layer, top of Kingsmill section, Penn t.,	259
" red shales make Fisher Creek valley; slope of Cove mountain; terrace; continuous with Pine hill; fertile soil,	316
" 6000' in Rye t., vertical dip,	316
" occupies all S. and S. E. of Watts t., good soil,	384
" folded and much contorted in Watts t.,	384
" 6000' throughout Watts t.,	384
" covers all extreme S. of Wheatfield t.,	394
" lower division distinguished by its plants,	395
" middle and upper divisions make Pine hill,	395
" thickness obscured by small rolls,	395
<i>Formation No. X, Pocono sandstone.</i>	
" described,	78
" ore beds,	102
" 2000', dip 65° N. Buffalo t., Berry mtn.,	152
" coal in Berry mtn.,	152
" in Greenwood t., High knob,	221
" crest of Buffalo mtn.,	245
" coal at Duncannon,	292
<i>Formation No. XI, Mauch Chunk red shale.</i>	
" 1500' left in the Cove,	79
" some beds calcareous enough to furnish hard farm water,	293
" altered by trap dyke—Penn t.,	296

LIST OF FOSSILS MENTIONED IN THE REPORT.

<i>Astrocerium</i> , in rubbly bed VI b,	183
<i>Atrypa reticularis</i> , in VIII b 2,	193
" " in VIII b 3,	339
<i>Autopora</i> bed, in VI b,	183

	Page.
<i>Avicula</i> ; see <i>Cardiola</i> ,	69
<i>Beyrichia</i> in VIII b 2,	193
“ bed in VI b,	60
“ bed low in VI b,	182
“ abundant in V below red shale,	256
“ in VI solid blue limestone,	337
“ abundant in V b,	373
<i>Beyrichia</i> fill the Kingsmill shales VIII-IX,	77,291
<i>Beyrichia granulata</i> bed in VI b,	60,182
<i>Beyrichia lata</i> , in V a upper shales,	50
“ “ in V a, Ore sandrock,	50
“ “ in V b, Sand vein ore bed,	50
<i>Beyrichia notata</i> , in V b, over Sand vein ore bed,	51
“ “ in V b, red shale,	51
“ “ argued from,	56
<i>Bothriolepis</i> scales in IX; (see Fish,)	73,291
Brachiopods in Kingsmill SS., VIII-IX,	165,393
Calamites in X,	154
<i>Calymene Blumenbachii</i> in V a,	50
“ <i>Clintoni</i> in V a, V b,	50
“ in VI b,	183
<i>Cardiola</i> (<i>Avicula</i>) <i>speciosa</i> in VIII c, Portage,	69
“ shales,	85,281
<i>Chonetes</i> , in VI b,	182
<i>Cladopora fibrosa</i> ? bed in VI b,	183
Coprolite? bed in Kingsmill SS., VIII-IX,	289
Coral bed of VI well developed,	160
“ “ of VI b,	182,338
Corals silicified,	161,183
<i>Cornulites</i> , VI b,	183
Crinoidal joints in VI c,	62
“ in VIII c 3,	206
“ beds in VI b,	260
“ in VIII c 1,	343
Crustaceans; see <i>Beyrichia</i> ,	77
<i>Dalmanites</i> ? in VIII b 3,	339
<i>Delthyris</i> shaly limestone, VI b,	60
<i>Discina discus</i> in VI b,	61,260
<i>Encrinital</i> limestone, VI d, e,	60
<i>Encrinites</i> in VIII f,	225
<i>Eurypterus</i> ,	57
<i>Favosites</i> small in VI b,	182,260
<i>Fenestella</i> shale, VIII c 3,	69,204,205,206,315,390
Fish beds in IX,	73,75
Fish scales, in VIII-IX,	289,290,291,324
<i>Grammysia elliptica</i> , in VIII f,	328
<i>Holoptychius</i> ? scales in IX, (see Fish,)	73,291
<i>Homælonotus dekayi</i> , in VIII c 2,	203
Lamellibranchs in V a, Va,	51
“ in VIII-IX,	73

	Page.
<i>Leperditia alta</i> in V b,	51,54,257,259,372,373
“ “ in VI,	55,242
“ “ in VI a,	61,180
“ “ in VI b,	182
<i>Leptaena</i> bed in VI b,	60,182
<i>Lingula oblonga</i> in Vb,	51
“ “ in VIII-IX,	167
<i>Megambonia aviculoidea</i> , in VI b,	61
<i>Merestella bella</i> , in VI b,	61,260
“ <i>laevis</i> , in VI b,	61,183,259,260
<i>Murchisonia minuta</i> , in VI b,	60,61,182,184
“ large, in VIII c 2,	203
<i>Ormoceras vertebratum</i> in V b,	50
<i>Orthis oblata</i> , in VI b,	183
<i>Paracyclas lirata</i> , VIII c 3,	69,205,272,273,333
Pentamerus upper limestone,	60
Pentamerus lower limestone,	60
Plant beds,	77,166,167,289
<i>Platyceras</i> ,	61
Polyzoon bed in VI b,	60
Polyzoa plentiful in VIII f,	166
<i>Poteriocrinus</i> in VIII f,	166
<i>Productella hirsuta</i> in VIII f,	225
<i>Rensselaeria mutabilis</i> in VI b,	61
“ in VII,	37,38
“ <i>Marylandica</i> ? VIII c 2,	203,314
Rhizocarps,	65
<i>Rhynchonella</i> beds in VI b,	60,182,184
<i>Rhynchonella formosa</i> in VI b,	61,218,260,337
“ <i>mutabilis</i> , VI b,	183
“ <i>nucleolata</i> , VI b,	61
<i>Schizodus rhombens</i> , VIII-IX; (see Fish,)	73,74,291
<i>Sphaerocystites multifasciatus</i> , VI b,	60,182
<i>Spirifera arenosa</i> , in VII,	190
“ <i>disjuncta</i> , VIII-IX,	74,77,289,291
“ <i>formosa</i> , VIII c 2,	203
“ <i>granulifera</i> , VIII c 3,	328
“ <i>macropleura</i> , VI, c	62
“ <i>mesocostalis</i> , VIII f,	166,225
“ <i>mesostriatis</i> , VIII-IX,	73,290
“ <i>modesta</i> , VI,	218
“ <i>Vanuxemi</i> , VI b,	61,183
Sporangia, minute, VIII b 5,	65,341
<i>Streptelasma</i> , in VI b,	184
<i>Stromatopora</i> (coral) bed, VI b,	60,182,337
<i>Strophodontu demissa</i> , VIII f,	225
<i>Strophomena rugosa</i> , VI b, c,	61,62,182
<i>Styliola fissurella</i> , VIII d, Genessee,	69
“ “ VIII c 3,	206
<i>Syringopora?</i> in VI b,	182

	Page.
<i>Tentaculites attenuatus</i> , VIII c 2,	203
“ <i>gyracanthus</i> , VI a, b,	61, 182, 260
“ <i>irregularis</i> , VI a,	61
“ <i>ornatus</i> , VI a, b,	61
Tentaculite beds, VI a, b,	60, 182, 183
<i>Trematopora</i> (coral) bed, VI b,	182, 260
Trilobites in VIII b 3,	339
<i>Tropidoleptus carinatus</i> beds, VIII c 3,	69, 203, 205, 206, 210, 273, 383
<i>Vitulina pustulosa</i> , VIII c 3,	206



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For the coal basins of POTTER county see G 3.

For the coal basins of CLINTON county see G 4.

For the coal in WAYNE county see G 5.

For the East Broad Top coal basin in HUNTINGDON county see F.

For the mountain coals in BLAIR county see T.

For the Broad Top coal measures in BEDFORD and FULTON counties see T 2.

For the coal basins in CENTRE county see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

PETROLEUM AND GAS.

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See also report on the line of the Terminal Moraine, Z.

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C 4. Report on CHESTER county; General description, pp. 214, by J. P. Lesley; Field notes in the townships, pp. 215-354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists, and 12 page plates. 8°, pp. 394, 1883. Price \$0 75, postage \$0 18.

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Grand atlas, Div.	G.	K.	R.
II, Pt. I.	G 2.	K 2.	R atlas.
Grand atlas, Div.	G 3.	K 3.	R 2 atlas.
I, Pt. I.	G 4.	K 4, Pt. I.	T.
B.	G 5.	L.	T atlas.
B 2, (exhausted.)	G 6.	M.	T 2.
C.	G 7.	M 2.	T 4.
C 2.	H.	M 3.	V.
C 3.	H 2.	N.	V 2.
C 3 atlas.	H 3.	O.	Z.
C 4.	H 4.	O 2.	—
C 6.	H 5.	P, Vols. I, II.	75.
D.	H 6.	P, Vol. III.	

Other reports of the Survey are in the hands of the State Printer and will soon be published.

SINGLE SHEETS ANTHRACITE REGION.

In order to make the results of the survey in this region immediately available, 200 copies of each sheet (size 26×32 inches) will be sold singly as soon as printed. Remittances* for the same and communications respecting the Anthracite Survey should be addressed to

CHAS. A. ASHBURNER, *Geologist in Charge,*
907 Walnut street, Philadelphia.

General Map Anthracite Coal Fields, scale $\frac{1}{380000}$ ths of nature (about $4\frac{1}{4}$ miles to one inch) showing the outlines of the coal basins and outlets to market; with list of working mines during 1882 and 1883 with their annual production,

Printed on light paper, Price \$0 11
Printed on heavy paper, Price \$0 12
Printed on light paper with counties colored, Price \$0 13

Geological and Mine Sheets, scale 800 feet to 1 inch $\frac{1}{380000}$ ths of nature, showing the geology, mine workings, and the shape of the floor of the coal beds by contour curve lines 50 feet vertically apart.

DELANO SHEET¹, Western Middle Field, in vicinity of Delano
and East Mahanoy City, Price \$0 22
SHENANDOAH SHEET¹, Western Middle Field, in vicinity of
West Mahanoy City, Shenandoah, and Gilberton, Price \$0 26

*The price assigned to each sheet includes one cent for postage. Where less than 10 sheets are ordered for one delivery, 5 cents must be remitted in addition to the price of the sheets, to pay for a paste-board tube and postage thereon.

GIRARDVILLE SHEET ¹ , Western Middle Field, in vicinity of Frackville and Girardville,	Price \$0 24
ASHLAND SHEET ¹ , Western Middle Field, in vicinity of Ashland, Locust Dale, Centralia, and Montana,	Price \$0 31
NANTICOKE SHEET ² , Northern Field, in vicinity of Nanticoke and Newport,	Price \$0 31
WARRIOR RUN SHEET ² , Northern Field, in vicinity of Warrior Run and Hanover; contains also skeleton map between Wilkes Barre and Shickshinny, (scale, 1 mile=1 inch,)	Price \$0 26
PLYMOUTH SHEET ² , Northern Field, in vicinity of Plymouth,	Price \$0 31
ASHLEY SHEET ² , Northern Field, in vicinity of Sugar Notch, Ashley, and South Wilkes Barre,	Price \$0 31
KINGSTON SHEET ² , Northern Field, in vicinity of Kingston and Plains,	Price \$0 36
WILKES BARRE SHEET ² , Northern Field, in vicinity of Wilkes Barre,	Price \$0 36
DRIFTON SHEET ³ , Eastern Middle Field, in vicinity of Drifton, Jeddo, Ebervale, Stockton, &c.,	Price \$
HAZLETON SHEET ³ , Eastern Middle Field, in vicinity of Lattimer, Hollywood, Harleigh, Hazleton, Mt. Pleasant, &c.,	Price \$
MAUCH CHUNK SHEET ⁴ , Southern Field, in vicinity of Mauch Chunk and Nesquehoning. (See foot-note, page 4.)	
LANSFORD SHEET ⁴ , Southern Field, in vicinity of Lansford and Summit Hill. (See foot-note, page 4.)	
TAMAQUA SHEET ⁴ , Southern Field, in the vicinity of Coaldale and Tamaqua. (See foot-note, page 4.)	

Topographical Sheets, scale 1600 feet to 1 inch $\frac{1}{19200}$ ths of nature, showing surface topography in contour curve lines 10 feet vertically apart.

SHEET No. I,	{ in vicinity of Delano and Mahanoy	
WESTERN MIDDLE FIELD ¹	{ City,	Price \$0 11
SHEET No. II,	{ in vicinity of Shenandoah, New Bos-	
WESTERN MIDDLE FIELD ¹	{ ton, Frackville, Girardville, &c.,	Price \$0 11
SHEET No. III,	{ in vicinity of Centralia, Ashland,	
WESTERN MIDDLE FIELD ¹	{ Mt. Carmel, &c.,	Price \$0 11
SHEET No. I,	{ in vicinity of Mauch Chunk, Lans-	
SOUTHERN FIELD ⁴ ,	{ ford, Tamaqua, &c. (See foot-note, page 4.)	

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1. Contained in Atlas W. M. A. F. Part I.
 2. Contained in Atlas N. A. F. Part I.
 3. Contained in Atlas E. M. A. F. Part I.
 4. Contained in Atlas S. A. F. Part I.

Cross Section Sheets contain vertical cross sections, scale 400 feet to 1 inch, $\frac{1}{4800}$ ths of nature; reference maps scale 1 mile to 1 inch, $\frac{1}{33333}$ ths of nature; &c.

SHEET No. I, WESTERN MIDDLE FIELD ¹	{ 4 sections through Myersville, Coplay, Morris, West Lehigh, Schuylkill, Glendon, Primrose, Hillside, Oak Hollow, Barry, Yatesville, Mahanoy City, Elmwood, Tunnel Ridge, and Middle Lehigh Collieries and East Mahanoy R. tunnel, Price \$0 09
SHEET No. II, WESTERN MIDDLE FIELD ¹	{ 5 sections through Indian Ridge, Plank Ridge, Knickerbocker, Shepandoah City, Coal Run, St. Nicholas, Boston Run, Lehigh No. 3, Packer Nos. 2 and 4, William Penn, Bear Ridge Nos. 1 and 2, Stanton, Draper, Colorado, Lawrence, and Ellangowan collieries, Price \$0 09
SHEET No. III, WESTERN MIDDLE FIELD ¹	{ 4 sections through Girard Mammoth, Cuyler, Hammond, Continental, North Ashland, Preston Nos. 1, 2, 3, and 4, Centralia, Hazle Dell, Bast, Tunnel, Big Run, Keystone, Potts and Franklin collieries, Price \$0 09
SHEET No. IV, WESTERN MIDDLE FIELD ¹	{ Sections through Mt. Carmel, Rough and Ready, Coal Ridge No. 3, Bellmore and Reno collieries; longitudinal section Mahanoy basin and geological map between Delano and Ashland, (scale 3200 feet=1 inch,) Price \$0 11
SHEET No. III, NORTHERN FIELD ² ,	{ 10 sections; through Boston, Plymouth Nos. 1, 2, and 4, Dodson, Gaylord, Avondale, Nottingham, Reynolds, Franklin, and Sugar Notch Nos. 9 and 10 collieries, . . Price \$0 09
SHEET No. IV, NORTHERN FIELD ² ,	{ 10 sections; through Maltby, Enterprise, Forty Fort, Wyoming, "Harry E," Black Diamond, Mill Hollow, East Boston, Kingston, Henry, Burroughs, Prospect, and Midvale collieries, Price \$0 09
SHEET No. V, NORTHERN FIELD ²	{ 5 sections; through Pine Ridge, Mill Creek, Laurel Run, Conyngnam, Baltimore, Diamond (No. 1,) Hollenback (No. 2,) Red Ash, Empire Nos. 3 and 4, and Stanton collieries, Price \$0 09

SHEET No. I, EASTERN MIDDLE FIELD ³ ,	{ 5 general sections, scale 800 feet to 1 inch; through Highland, Eckley, Woodside, Stockton, Hollywood, Hazleton, Mt. Pleasant, &c., col- lieries, Price \$
SHEET No. II, EASTERN MIDDLE-FIELD ³ ,	{ 16 sections; through Highland, Woodside, Drifton, Eckley, Lat- timer, Jeddo, Milnesville, Eber- vale, Hollywood, Harleigh, &c., collieries, Price \$
SHEET No. III, EASTERN MIDDLE FIELD ³ ,	{ 9 sections; through Lumber Yard, Stockton, Diamond, Hazleton, Cranberry, Crystal Ridge, &c., collieries, Price \$
SHEET NOS. I, II and III, SOUTHERN FIELD ⁴ ,	{ 25 sections; through collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)

Columnar Section Sheets contain sections showing thickness and character of coal measures, scale 40 feet to 1 inch, of coal beds scale 10 feet to 1 inch, &c., &c.

SHEET No. I, NORTHERN FIELD ² ,	{ contains sections at Bennett, Pine Ridge, Enterprise, Henry, Wy- oming, Oakwood, Prospect, Con- yngham, Baltimore, Diamond, Hollenback, Laurel Run, Min- eral Spring, and Red Ash col- lieries, Price \$0 11
SHEET No. II, NORTHERN FIELD ² ,	{ contains sections at Dorrance, Em- pire Nos. 2 and 4, Kidder, Stan- ton, South Wilkes Barre, Frank- lin, Sugar Notch, Ashley No. 6, Hillman Vein, &c., collieries . . Price \$0 11
SHEET No. III, NORTHERN FIELD ² ,	{ contains sections at Maltby, Forty Fort, Harry E, Black Diamond, East Boston, Kingston, Mill Hol- low, Plymouth, Boston, &c., col- lieries, Price \$0 11
SHEET No. IV, NORTHERN FIELD ² ,	{ contains sections at Plymouth, Lance, Gaylord, Dodson, Wana- mie, Alden, Avondale, Chaun- cey, Nottingham, Susquehanna Nos. 1 and 2, Hanover, Warrior Run, &c., collieries, Price \$0 11
SHEETS NOS. I, II & III, SOUTHERN FIELD ⁴ ,	{ contains 79 sections at collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)

Other Anthracite sheets are in the hands of the State Printer and will soon be printed.

The sale of the reports is conducted in accordance with the provisions of Section 10 of the Act of the 14th day of May, 1874, which directs that copies of the Reports, with all maps and supplements, shall be furnished *at cost of publication to all applicants for them.*

All the printed volumes and maps in stock have been transferred by the Board of Commissioners to the Department of Internal Affairs, where the sales thereof will hereafter be conducted.

Communications relating to the work of the Survey should be addressed to J. P. Lesley, State Geologist, No. 1003 Clinton street, Philadelphia, and those intended for the Board of Commissioners to William A. Ingham, Secretary, No. 907 Walnut street, Philadelphia.

For instructions for purchase of single sheets of the Anthracite Survey, see page 9.

All letters and orders concerning the purchase of Reports and remittances for the same, should be addressed to

J. SIMPSON AFRICA,
Secretary of Internal Affairs
Harrisburg, Pa.

March 1, 1885.







SECOND GEOLOGICAL SURVEY
OF PENNSYLVANIA
J.P. LESLEY, STATE GEOLOGIST.

EXPLANATION OF COLORS.

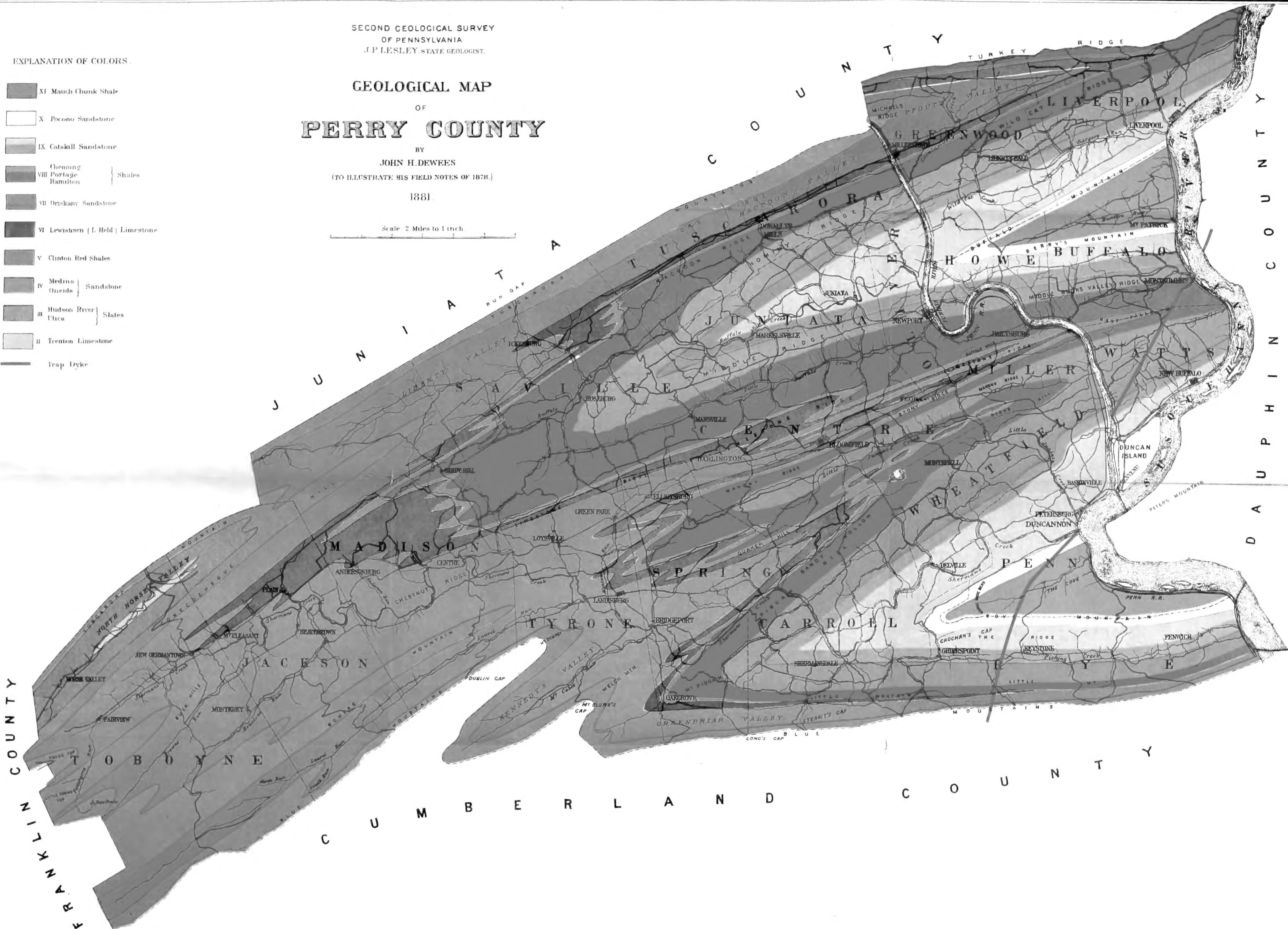
- XI Mauch Chunk Shale
- X Pocono Sandstone
- IX Catskill Sandstone
- Chemung
VIII Portage
Hamilton } Shales
- VII Oriskany Sandstone
- VI Lewistown (L. Held) Limestone
- V Clinton Red Shales
- IV Medina
Oneida } Sandstone
- III Hudson River
Ulica } Slates
- II Trenton Limestone
- Trap Dyke

GEOLOGICAL MAP
OF
PERRY COUNTY

BY
JOHN H. DEWEES
(TO ILLUSTRATE HIS FIELD NOTES OF 1878.)



















1881

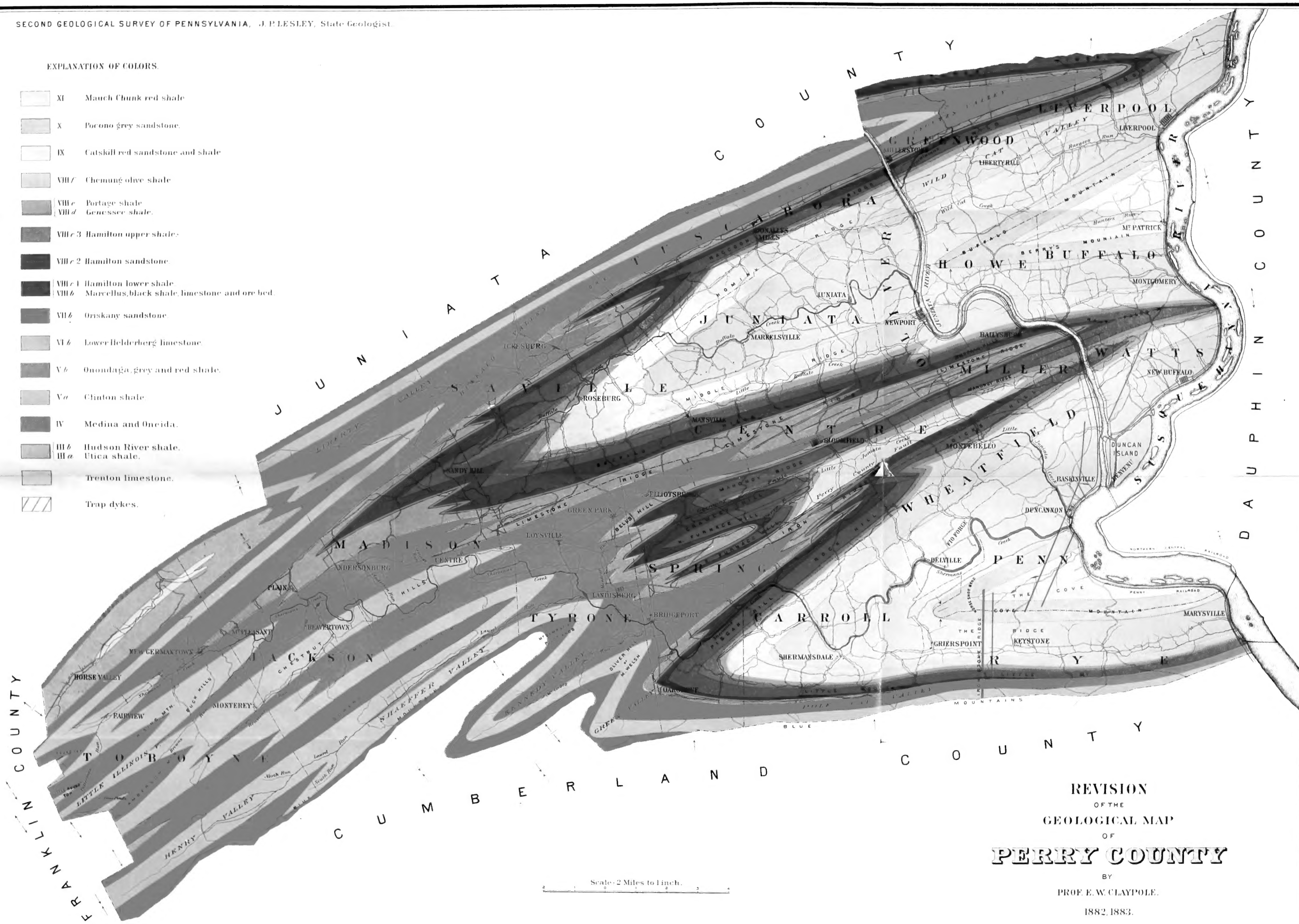
Scale: 2 Miles to 1 inch.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA, J. P. LESLEY, State Geologist.

EXPLANATION OF COLORS.

-  XI Mauch Chunk red shale
-  X Pocono grey sandstone.
-  IX Catskill red sandstone and shale
-  VIII f Chemung olive shale
-  VIII e Portage shale
-  VIII d Genesee shale.
-  VIII c 3 Hamilton upper shale.
-  VIII c 2 Hamilton sandstone.
-  VIII c 1 Hamilton lower shale
-  VIII b Marcellus, black shale, limestone and ore bed.
-  VII b Oriskany sandstone.
-  VI b Lower Helderberg limestone.
-  V b Onondaga grey and red shale.
-  Va Clinton shale.
-  IV Medina and Oneida.
-  III b Hudson River shale, Utica shale.
-  Trenton limestone.
-  Trap dykes.



REVISION
OF THE
GEOLOGICAL MAP
OF
PERRY COUNTY
BY
PROF. E. W. CLAYPOLE.
1882, 1883.

